GAMETRONICS PROCEEDINGS

ELECTRONIC ENGINEERING TIMES

ELECTRONIC GAME SERIES GC-1

GAMETRONICS PROCEEDINGS

Chairman: Jerry Eimbinder
Program Chairman: John Tsantes
Arrangements: Margie Stenzler
Coordination: Robert Sugarman
Photography: Liane Enkelis
Registration: Elena Carelli
Staff: Dody Riggs, Cathy Figorito

GAMETRONICS

The Electronic Game Designer's Conference

Proceedings of the
First Annual Gametronics Conference
January 18-20, 1977
San Francisco

A billion dollar industry is in the making. Thanks to advances in integrated-circuit technologies, designers are contemplating game systems of startling sophistication and unprecedented player involvement.

The era of the electronic game is at hand. Its scope is limited by the creativity of the mind, not the ability of solid-state electronics. This is a time for resourcefulness, planning, courage and movement.

To help designers meet the challenges of the electronic games industry, a special conference was organized by Electronic Engineering Times. Called "Gametronics," this conference brings together active and prospective participants in game design and production with leading suppliers of components for electronic games.

Electronic Engineering Times

280 Community Drive
Great Neck, New York 11021

gg -direct


GAMETRONICS
1977

TABLE OF CONTENTS

TELEVISION GAMES
THEIR PAST, PRESENT AND FUTURE

RALPH H. BAER
Manager, Consumer Products Developments
Sanders Associates, Inc.
Nashua, New Hampshire

The Home TV Game industry has just been through a year of unprecedented growth. By the end of Calendar 1976, somewhere between three and four million Home TV Games had been sold to U.S. consumers alone. All indications are that there is a demand for still larger quantities of TV Games in 1977.

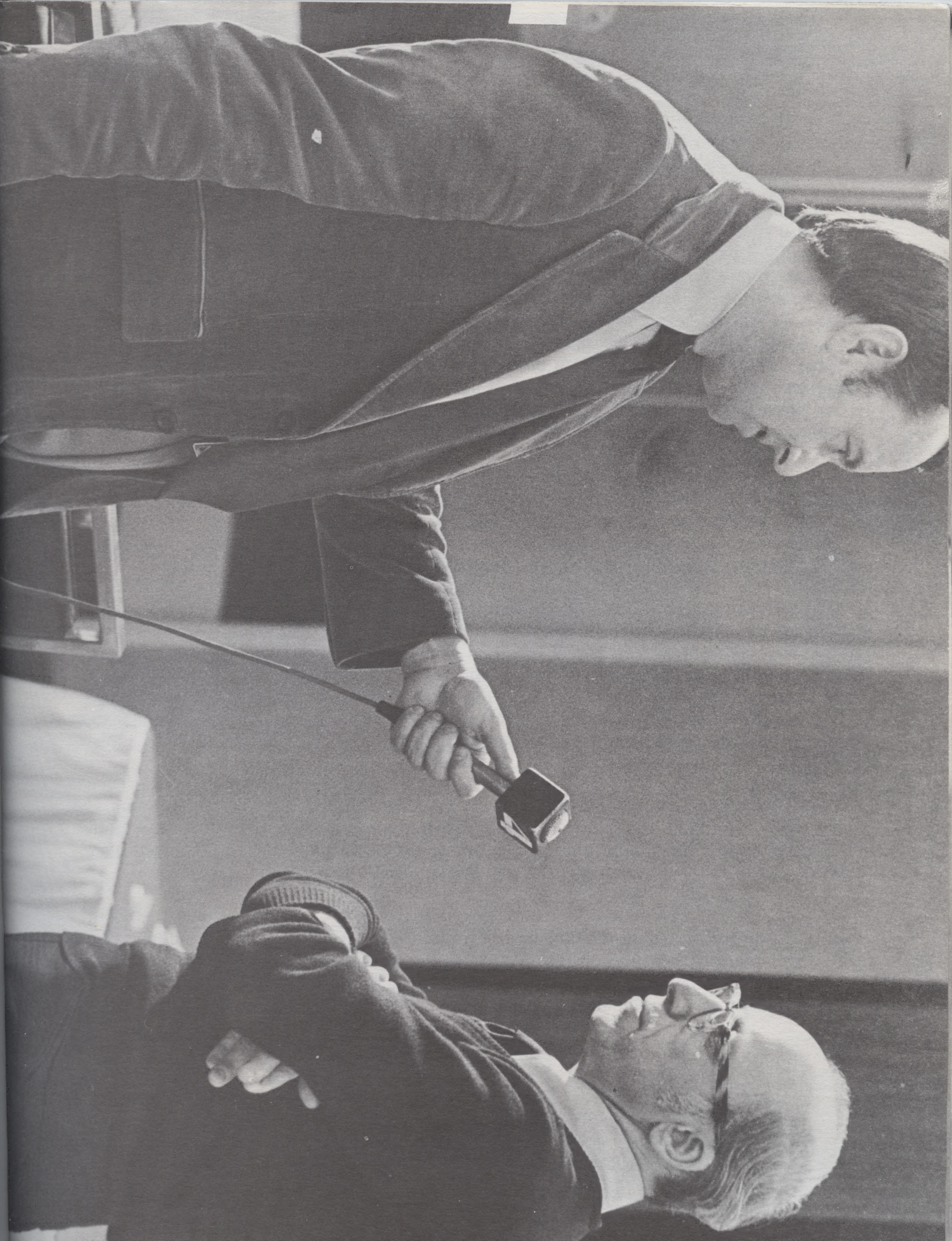
There were several engineers at Sanders Associates, Inc. who worked with me nearly a decade ago to get Home TV Games underway. With all due modesty, we now look with considerable satisfaction at the results of our pioneering efforts. It is not everyday that engineers can personally identify with the creation of a whole subindustry.

Furthermore, we have had the pleasure of staying close to continuing TV Game development activities at Sanders Associates, Inc. to the present day. As a result, I was happy to respond when I was asked to look at the Past, Present and Future of TV Games, and Home TV Games in particular. I hope that you will find the few minutes I am about to spend on reminiscencing, of interest; after that I will try to shed some light on where we are today and where future developments are likely to take us over the next several years.

I've often been asked how and when it all began, and I get the feeling that some people expect to hear some kind of an inspiring tale of divine revelation. Now, I wish I could oblige but I don't have to tell you that in real life, ideas rarely come out of thin air, and that what usually happens is pretty straightforward.

The background for my numerous TV Game related inventions starts with a degree in TV engineering which I obtained further back than I'd like to admit. The question of how to make use of home TV sets, other than watching over-the-air programs, had been bothering me since the early sixties. Now, again you don't have to go too far to find my motivation. That also has very little to do with divine inspiration. The fact is that even back then there were some 62 million TV homes - that is TV Homes, not TV sets. . . . There were well over a million TV sets, in the U.S. alone by 1965, and about as many again in the rest of the Western world and places like Japan and Australia. The idea of attaching some device to even a small fraction of that many TV sets was a pretty powerful incentive for coming up with something, anything, on which people might actually want to spend their money.

Page 1: ABC newscaster Ed Leslie and Ramtek president Chuck McEwan watch as ABC cameraman zooms in on Barricade.
Page 2: Jerry Eimbinder presents award to Nolan Bushnell.
Page 4: Magnavox game designer John Slusarski.
Page 6: Ralph Baer addressing Gametronics conference.



Well, you don't have to be a mathematical genius to multiply, something even as conservative as 10% of 100 million TV sets by almost any dollar number. Obviously you will come up with a really interesting business proposition, so when the idea for playing interactive TV Games came to me in the mid-sixties, I can honestly tell you that I had a very strong feeling even then, that I was holding a tiger by the tail.

At the time, I was running the Equipment Design Division at Sanders Associates, Inc. in Nashua, N. H. Sanders is a $200 million a year electronic systems development and manufacturing organization comprised of a number of operating divisions. At various times in the past, my Division had as many as 500 engineers, technicians and support people in it; but as you might guess, there was not a single TV raster-scan related project around and very few engineers who knew much, if anything about TV. I decided to build my own breadboard and check out my initial ideas for generating player spots and moving them around a broadcast TV receiver screen under manual control. I figured I'd do the work myself after hours. — I've always been close to the bench activities in my various labs at Sanders, but obviously, when you run a large organization you have no business fooling around on the bench yourself. I've known other engineering managers who tried to handle this situation by building small labs behind their offices where they figured they could get their engineering licks in at odd moments. But when the phone rings all day long or you're out on travel, or you are buried in reports and forecast and people problems, there is no time and normally little stomach for mucking around in your lab. Anyway, I did start to build a couple of symbol generators myself late in '66 and pretty soon I had two spots chasing each other around the screen of a black-and-white TV set that was hanging around one of the labs for one reason or another.

At about that time it became pretty obvious to me that I had the elements of a fun game, and I was considerably encouraged to push ahead. It became also pretty clear to me that I had to get this effort organized and stepped up by making it an official program activity. Both our Director of R&D, Herbert Campman and our Corporate Director of Patents, Louis Etlinger, shared my early enthusiasm for the possibilities of TV Games, so we moved the activities into a closed area and brought in Bill Harrison and Bill Rusch to work with me on what had now become an official IR&D project.

Bill Harrison started out all by himself in a small room on the sixth floor of our Canal Street facility; into which we moved a single lab bench and a desk. Bill Rusch had an office somewhere else and was still working on the tail end of some other projects. I would pop in and out of the room as often as I could and Bill Harrison would do all the bench work. The three of us had keys to the room and the place was off-limits for everybody else. There are perhaps 200 to 300 engineering and technical support people on that floor, and our lab was right next to the main elevator. Soon the rumor mill was going full blast about what was going on in THAT room, and we really stoked the rumor-mill

NBC newscaster Jack Bates is filled in on the development of TV games by Ralph Baer.


ELECTRONICS
RALPH BAER
ASSOCIATES

because of one of the part-time projects on which Bill Rusch worked on after he joined the group. This was an invention of his which involved a very clever conversion of electric guitar strings tones to tones one octave lower than those of the natural string, but with the same dynamics. As you might imagine, the sound of guitar music coming out of that room next to the elevator wasn't the kind of thing you commonly hear around Sanders and helped us start some pretty convoluted rumors.

Within a couple of months, our TV Game project had made considerable progress. We had bought an RCA 17" color TV console set early in 1967 and believe it, or not, here we were fully ten years ago, playing chase games, target games and a little later on, the first fully interactive Ping-Pong and Hockey games, with color and FM sound through the TV set. Even our earliest Ping-Pong games were played against a green background, while, naturally, Hockey was played against a background of blue ice.

While I am on the subject you might be interested in how we handled color signal generation back then. I imagine some of you are working on color right about now. So let me break into the story for a minute and do just that. What we did was extremely simple and took one NPN 6 1/2 cent transistor, 2 diodes, a few resistors and capacitors, and a 3.58 MC chroma crystal and a 15 cent oscillator tank coil. With these parts we built the chroma oscillator and thru the use of a center-tapped secondary on the tank coil we obtained two 3.58 MC signals 180° out of phase with each other. Taking an output from one side of this secondary and gating it into video with horizontal sync pulses gave us an adequate approximation to a color burst reference signal. Then we connected an RC phase shift network across the secondary outer terminals, the resistor being a potentiometer, so that the phase at the junction of the resistor and capacitor could be varied nearly 0 to 180° with respect to the color burst reference phase. Then we used horizontal sync to gate out this new phase signal via the second 3 cent diode, again into video, and presto we had background color; there was also some color fringing around the paddles and the ball that sort of came along for free and looked pretty attractive, so we left it alone.

Going back to our sixth floor lab, we find Bill Rusch who has meanwhile moved his desk in there and is grinding out ideas by the yard. Pretty soon we had some very complex game actions underway. They were all done in discrete components, which may seem strange, but isn't really, when you remember that this was 1967. At that time the only IC's available were DTL, and RTL and high speed MECL. The average cost of an ordinary multiple gate device was well over a dollar in large quantities and IC power consumption was such as to preclude their use in battery operated Home TV Games. We kept an IC design effort going for a short while but got pretty unhappy with it and left that design approach to posterity. It was just too hard to beat discrete designs built out of nickel transistors and 3 diodes so we didn't give it another thought and ploughed ahead.

Ralph Baer receives Gametronics award for pioneering work in TV game design from Jerry Eimbinder, Publisher of Electronic Engineering Times.


GAMETRONICS
'77
HYATT

About that time we decided that if we could get realistic ball motion, we could build multiple-participant hockey games with joystick control over the players. We figured that sitting in a bar, and using the TV set which is usually perched on a shelf above the booze, we could get a hell of game going if the action were challenging enough. Out of that idea came circuitry that moved the ball in a realistic fashion; that is, the ball moved in the direction into which it was hit by the puck-spots and with a velocity proportional to how hard it was hit. To this we added 4-wall-bounce and presto, we had ourselves a fantastic hockey game. We could dribble the ball, glove it, shoot it across the ice, hand it off to other players; and an adjustment changed the ice conditions from fast to sloppy to give beginners a chance.

How did we do it? Basically, what we did was to take the derivative of the paddle speed in two coordinates, i.e., the rate-of-change of paddle motion in the horizontal and in the vertical direction. Then, we stored these values of $\frac{de}{dt}$ in a sample-and-hold circuit at the moment of paddle-and-ball intercept and used this voltage to drive the puck generator circuits. All this has long since become a part of our extensive patent portfolio, which by now adds up to well over fifty U.S. and world wide patents, so you can read all about it if you like. I might add that we built a similar Hockey Game a couple of years ago in T^2L which also plays a terrific game. It still occupies the coffee break periods of a new generation of TV game engineers at Sanders, because it plays about 5 times as well as anything out there so far; only GI's brand new ball game LSI chip which was shown for the first time just last week at the CES Show, comes close to the action of our Skate-N-Score Hockey Game. I might also add that Skate-N-Score is strictly a competition piece - you either play someone who is your peer or you wind up with a lopsided score. For that reason I never play against the guys in my TV Game lab who are addicted to the game. There is no point in volunteering to take a 12 to 2 shellacking.

This brings up another point: in the past, manufacturers of TV Games have paid close attention to a rule that says: "You shall design games such that almost anyone can play almost immediately without reading instructions and such that he can score points right away." These guidelines are normally adhered to by designers of coin-operated TV Games for all the obvious reasons. As a result, when you first expose someone to a game of the Skate-N-Score variety, the initial reactions generally are often negative. If your participant is over 35 years old, his first comment will almost invariably be: "How do you score with this damn thing?" — Younger people generally get the hang of it in a few minutes and then proceed to have a hell of a good time.

Now, this presents a real problem in the sense that judgment on new home TV games is generally passed prior to their public sale by such people as department store buyers, mail order buyers, and management people of prospective TV Game manufacturers who depend on GI, MOS Technology, National Semiconductor, T.I., or other IC manufacturers to provide the LSI devices for their TV Game products.

Jerry Eimbinder opens activities at Gametronics.

The question is: "How do you effectively demonstrate and sell a product that is just plain hard to play at first?" I'll let you answer that question for yourself, but I'll say this much: The prevailing attitudes among the buyers are beginning to change and it's beginning to dawn on people that games with lasting play interest may require a learning process, just as it takes time to become proficient in real-life Ping-Pong, or card games, for example.

What this probably says, is that different design approaches to home TV Games vs coin operated games are in order and I believe you will see that trend reflected in the upcoming crop of 1977 Home TV Games.

Let me go back, for a few more minutes, to cap off the story on the beginnings of Home TV Games. It is probably common knowledge by now that Sanders decided to license the patents which I referred to earlier to one of a number of interested TV receiver manufacturers. Eventually Magnavox expressed a serious interest in building a number of hand tooled units based on our latest Home TV Game designs and market acceptance-testing them at several of their Home Entertainment Center locations in the U. S. An agreement for these tests was worked out in 1971. Actual test results were very encouraging and led to a license agreement between Magnavox and Sanders for their exclusive use of our patents and for rights to sublicense these patents.

The rest is familiar history. Magnavox publicly demonstrated their first Odyssey Home TV Game product in May of 1972 and managed to have substantial production capability on-line by the summer of 1972 to support the first wave of TV Game sales for the Fall and Christmas season of that year. And a pretty good start it turned out to be. In spite of the fact that Magnavox, through their initial advertising, managed to get the idea implanted in people's mind that Odyssey could only be played on Magnavox TV sets, nearly one hundred thousand games and game accessories were sold that short Fall and Winter season; and it has been upward and onward ever since, with ATARI joining the fray in 1975 and a still larger number of substantial suppliers appearing on the scene in 1976.

Some idea of the quantities of Home TV Games sold this past season can be inferred from General Instrument's announcement last month of the shipment of their five-millionth AY-8500 LSI game chip. It can safely be assumed, that the majority of these chips went into merchandise delivered to the shelves of U.S. and some foreign stores and from there to the homes of the TV Ping-Pong, Hockey and Handball players of America, Canada, and a few other places.

So here we are in January of 1977, with a big Home TV Game season behind us and sales at price levels that are just about in line with what I was directing my efforts to almost ten years ago - when I kept making noises about multifunction games for $29.95 - which is, of course, just about where we are in terms of today's dollars. Now the question is: Where are we going next?

Gametronics attendee tries Ramtek's Horoscope.

Some people ask the question a little differently: They ask where will it all end. That one is easy to field - it just won't end. I don't think I have to lecture you on the subject: Home TV Games will broaden and branch out in step with LSI technology advances; there will be low end, low cost machines like the past year's crop for years to come; newer, more complex games will fill the middle level needs for the next two years or so, and microprocessor controlled Home TV Games which had their start with Fairchild's VES, will get more and more ubiquitous. You know all that. We all read the same articles in Electronic Engineering Times and probably hear the same open secrets from various IC manufacturers representatives. So in the main, I'll try not to bore you by rehashing that same collection of real facts and lesser "facts" and do some prognosticating about areas which haven't been talked to death as yet.

Just to make sure we are all at the same starting line let me summarize very briefly where I think the Home TV Game industry is headed in 1977.

(1) First of all there will be another rash of AY-8500 GI chip-related games. This year's lower AY-8500 price and other P.C. board and component cost reduction efforts by reputable manufacturers will certainly result in well under $40.00 pricing for these staple games. Also at the low end of the scale, there will be some offerings put together from TI's T^2L game chips.

(2) Next there will be more GI AY-8500 types of games with color added, i.e., colored backgrounds, distinctively colored paddles and ball like this year's Odyssey 400, - not just rainbow background colors - my guess is that these games will be slotted in the same price ballpark in which this past year's GI chip black-and-white machines were selling.

(3) A larger number of manufacturers will offer accessory devices such as the target pistol and rifle, in conjunction with a basic paddle game chip unit and the accessories will perform better. For example, rifles will be less susceptible to ambient light problems, pistols won't pop off when Junior waves them past Mother's reading lamp, and so forth.

(4) Next, the new generation of GI, MOS Technology, Inc. and other standard and semi-custom chips with user dictated PROMS will show up in the $50 to $100.00 retail slot. Among these will be GI's new joystick controlled ball game chip I already mentioned a while ago. If you haven't had any contact with this device before, I think you'll be startled by the game action it offers - like a Hockey Game with realistic ball action and such game features as passing and bouncing the ball between the net and the fence. Then, there will be surprising new games which take advantage of MOS Technology's chip with its customer specified on-chip PROM. A number of these are presently in the works - however since they all have PROM's with customer

Fingertip control of game action was demonstrated at Gametronics by I Corporation.


1977

Logic RAM, your character storage ROM and away you go with this week's hottest game - naturally, after having been properly instructed in the game rules through on-screen alpha-numeric messages and through pictorials also put onto your screen via local character generator hardware, again controlled by another piece of RAM which is also addressed by your friendly telephone line.

Alternatively, TV game clubs might spring up all over just as microprocessor-groups are doing right about now. More than likely some of the same people will weave through both of these areas - members will call each other and swap game programs, or maybe just trivia such as a better-looking hockey player symbol, all via their phone line, and probably through the latest LSI modem chip set right onto your $24.95 cassette deck.

Still another telephone application has you dialing the weather number just as you get out of bed in the morning, and your cooperative game microprocessor, doubling as a convenient character generator puts up the bad news on your TV screen. Clearly, I have just started to drift off into the territory which can no longer qualify for listing under the game heading - but I don't have to tell you that this flowing back and forth between games and other intelligent CRT terminal uses will become very commonplace in a few years.

So much for the telephone and TV Games. Next let's have a look at the Cable TV connection. There we have to distinguish between two technically very different environments: No. 1 today's common, one-way cable TV system; and No. 2, tomorrow's 2-way cable environment.

Let us limit this look at Cable TV Games to one-way systems. As you know, there are quite a few one-way systems in operation today, while two-way cable installations are still virtually non-existent.

We have addressed the question of how to play cable TV games - and what games to play - at Sanders at various times in the past, so I can speak from first hand experience on at least part of this subject. Let me take you through a list of several approaches to Cable TV Games:

Category 1. Interactive Sports Games with backgrounds, which might be a card table - a slot machine face - or a playing field, provided by a Cable Channel transmission. A simple example would be a hockey game played out of a TV Game device but superimposed on a colorful transmitted background.

Category 2. Interactive Sports Games as in 1. above, but with additional active symbology transmitted along with backgrounds by the cable. As an example, additional remotely generated hockey player symbols might appear on the TV screen. These would have the capability of interacting with other symbols, such as manually controlled ball players, or the ball itself.

Al Berglund, engineering planner for Walt Disney Productions, was one of the attendees at Gametronics.


Tank

Category 3. Interactive, Microprocessor Controlled TV Games in which digital data is transmitted to store game rules, character symbology, etc. needed for the operation of a particular game. This capability would most likely be complemented with cable-generated active player symbols and backgrounds as in Category 2. above.

Category 4. Home Viewer-Participant Game Shows. This is a class of CATV related games which may take the form of active participation by the home viewer in, say, a "What's My Line?" program; in scrabble-like word games originating on-stage, again with home viewer participation; and so on. The common denominator for these games is the ability to transmit digital data along with the customary visual pictorials to enter some form of viewer-owned display, such as a calculator type of readout.

Now, if you've followed me so far, you must have asked yourself whether any of these four ways of cable related electronic game areas can be accomplished with existing one-way cables, and, more importantly, with ordinary TV sets having no access to video or sync circuitry. This is the precise area we have addressed in our CATV game work at Sanders. Since some of this work has resulted in issued patents, I have no problem presenting this work here.

Let me first take a look at the technical requirements for Case No. 1, in which I used the example of TV Hockey Game superimposed on a transmitted background picture. The problem is one of obtaining horizontal and vertical sync from the received TV signal without making connections internal to the TV set. This is something we have learned to do well only recently, although practical ways of doing it are described in some of my issued patents based on disclosures I made and work done at Sanders in the sixties; secondly once vertical and horizontal sync are available and are used to phase lock the TV Game generation circuitry to establish synchronism, there remains the problem of adding the TV Game video information to that of the transmitted background picture. The solution to this problem is also described in these early patents. It involves the technique of amplitude modulating the rf signal just prior to entering the TV set antenna terminals; no new rf carrier generation is involved in this method of superimposing game video on incoming rf with composite video modulation; RFI is easily controlled and intercarrier sound operation is unimpaired.

Now let us look at the second cable games category in which I suggested, by way of an example, the transmission of prerecorded hockey player symbols along with background pictures. This is a more difficult technical problem and requires the availability of the composite video and sync signal received from the cable station by the Home Viewer's TV Set - or the availability within the viewer's game box of a separate RF front end, IF strip and video detector and sync stripper, tunable to one or two cable game channels - not too ridiculous a requirement in this day and age of linear TV IC's and surface wave bandpass

Pauline Sly listens to Dr. David Chandler describe Tank Squadron.


Instructions
Ramtek

filters; especially when you consider that we are dealing with RF signal levels typically in excess of one millivolt in a cable environment, so that a lot of gain is simply not required.

We have had such a system going at Sanders several years ago; at the time we generated a demonstration video tape in cooperation with Warner Communications people and facilities in the Boston area. This tape allows us to demonstrate a Cooperate CATV Game Channel transmission of a number of interactive sports games. The most interesting of these games was a Hockey Game in which both a colorful playing field was transmitted plus four randomly moving hockey player symbols, two goalies and two forwards. Our receiving equipment has the capability for recognizing the presence of these player symbols in real time; after that is done it is easy to introduce them into the logic circuitry of our Game Box and treat them just as though we had generated them in logic ourselves; as a result, these precanned player symbols can stop or reverse the ball motion and effectively interact with two manually controlled, locally generated player symbol of the ordinary variety. It is amazing how often the randomly moving, prerecorded player-symbols happen to be in the right place at the right time. When you watch or play a game like that you get the impression of playing with a couple of partners that at times play a terrific game and at other times can't seem to do anything right. What could be more natural than that?!

Looking ahead to future solutions for interactive games of this type, the use of Vertical Interval located digital data for game control comes to mind immediately. This comment applies both to my Category 2. and 3. Cable Games. The latter, you may remember, involve microprocessor aided Cable TV Games. As I indicated earlier, transmitting data to the computer's RAM or ROM storage during Vertical Interval is a natural technique.

In this connection a technique for transmitting digital data via a standard, unmodified TV set might be of interest to some of you. At Sanders we call this method a Digital Video Modem (Ref. 2) because it involves the transmission of data bitstreams at rates which can be many times that of vertical field rate, and which appears as a small, visible display in the corner of the TV picture. It is then photo-optically coupled into a digital decoder, much as you would use a telephone line modem for the recovery of transmitted digital data. This modem can be combined with the sync extraction and regeneration techniques I described earlier to provide data for microprocessor aided TV Games on one hand; or for the Category 4. games. Let me use the "What's My Line?" example again to illustrate this application of Digital Video Modems. In this situation, the home viewer might get privileged information, such as a multiple choice clues, as to the identify of the Mystery Guest. By using this transmitted digital data we can give the home viewer the satisfaction of beating the expert studio participants at their own game.

Horoscope, Ramtek's coin-operated, microprocessor-controlled system, is capable of providing five different charts, based on personal data input.


00 01:29 02

Let me finish this brief review and preview of cable games to come with this observation. I believe the techniques and incentives are now at hand to make a meaningful technical and marketing assault on one-way cable games possible. Whether the cable industry can be motivated to move in this direction remains to be seen. It is entirely possible that nothing will happen until that long awaited multifunction terminal appears which, in conjunction with a two-way cable, will let us do our shopping, meter reading, and all the other etceteras we've been reading about for years. When that happens, games will certainly be a part of such systems. But that part of the TV Game story comes under the heading of information to which many of us have been overexposed in the past, and I will stay away from that area, as promised.

A few minutes ago I talked about video tape recordings in conjunction with cable TV broadcast game programs. This leads me to the last TV Game related topic, and that is the future relationship between TV Games and Video Tape or Disc Playback Equipment.

Remember, the Sony cassette with the prerecorded Hockey Game I described in connection with Category 2. and 3. Cable Games? Obviously, if you eliminate the cable by putting the video tape deck into your living room and connecting your TV Game Box to the tape deck; you now have a video-tape-assisted hockey game you can play at home, in which both you and your opponent have a whole team playing for you on-screen.

Stretching our imagination a little further, we can visualize road-racing games in which our TV set becomes a convincing view through the windshield. While the pictorial imagary comes from the tape, we will do electronic processing of this video information to suit it to your steering wheel commands. Meanwhile digital data will be extracted from your video recording during Vertical Interval. It will allow your microprocessor to react to such things as sideswiping or collisions or running off the road, perhaps by using the digital data to identify various pictorial objects in terms of their location on screen.

At any rate, there is little doubt that once video tape or disc home entertainment systems have become a widely-accepted consumer product, a game playing capability will be one of the things you will find in every machine.

As digital memory gets cheaper, another thing that will happen will be the use of your color TV set as a canvas on which you can doodle, or paint seriously, if you will; again, your video recording equipment will serve as temporary or permanent storage, while you are in the process of painting, or after you have finished. Perhaps at sometime in the future when you ask a friend to come up and look at your etchings, you really mean to trot out your latest collection of video art for him — or her.

Fairchild's cartridge game records score and time remaining at bottom of screen.


hyatt house
WELCOME
ELECTRONIC
ENGINEERING
TIMES

Video disc or tape related TV Games are clearly not just around the corner; but again, technological developments, both in microprocessors, memories and other LSI components on the one hand; and the rapid acceptance of BETAMAX equipment on the other hand, point to a future marriage I expect that some of us will be present at the wedding.

Gametronics was conducted January 18-20, 1977 at the Burlingame Hyatt House (located near the San Francisco International Airport).

United States Patent [19]

Baer

[11] **3,993,861**

[45] **Nov. 23, 1976**

[54] **DIGITAL VIDEO MODULATION AND DEMODULATION SYSTEM**

[75] Inventor: **Ralph H. Baer,** Manchester, N.H.

[73] Assignee: **Sanders Associates, Inc.,** South Nashua, N.H.

[22] Filed: **Mar. 24, 1975**

[21] Appl. No.: **561,131**

[52] **U.S. Cl.** **178/5.6;** 178/DIG. 1

[51] **Int. Cl.**[2] **H04N 7/00**

[58] **Field of Search** .... 178/5.6, DIG. 1, DIG. 23, 178/DIG. 35, DIG. 38

[56] **References Cited**

UNITED STATES PATENTS

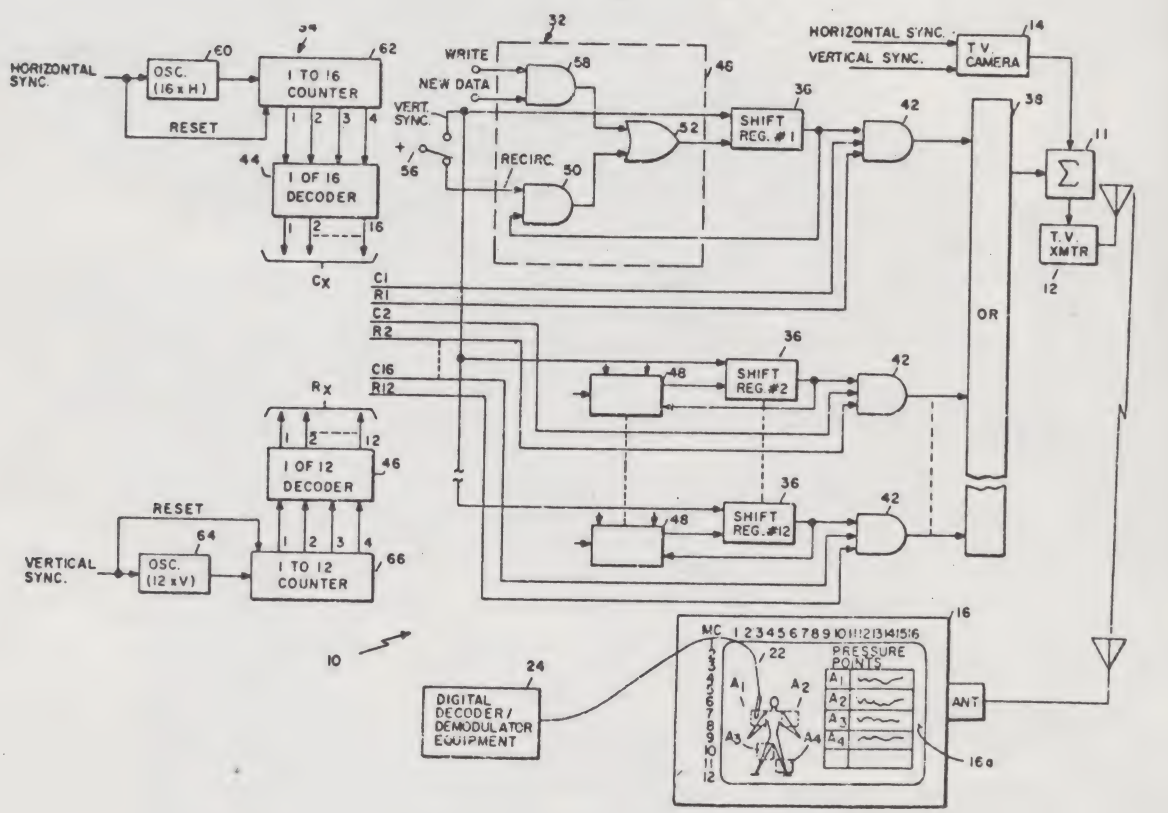
3,369,073	2/1968	Scholz	178/5.6
3,493,674	2/1970	Houghton	178/5.6
3,663,937	5/1972	Bolner	178/DIG. 1
3,728,480	4/1973	Baer	178/DIG. 1
3,737,566	6/1973	Baer et al.	178/5.8 R
3,743,767	7/1973	Bitzer et al.	178/DIG. 23
3,891,792	6/1975	Kimura	178/5.6 X
3,900,887	8/1975	Soga et al.	178/DIG. 23

Primary Examiner—Richard Murray
Assistant Examiner—Aristotelis M. Psitos
Attorney, Agent, or Firm—Louis Etlinger; Richard I. Seligman

[57] **ABSTRACT**

In a television system, a digital video system permits the transmission of data along with the usual television picture. The television picture field includes one or more selectively addressable areas and the data is impressed on these areas as digital, binary-coded brightness modulations at rates greater than the vertical field rate. At the receiving end of the system, the viewer positions one or more light sensors opposite these screen areas. The light sensors respond to the binary-coded brightness modulations by developing corresponding binary-coded digital electrical signals. The data stream from a light sensor can then be decoded by a demodulator/decoder operated by the viewer.

18 Claims, 6 Drawing Figures



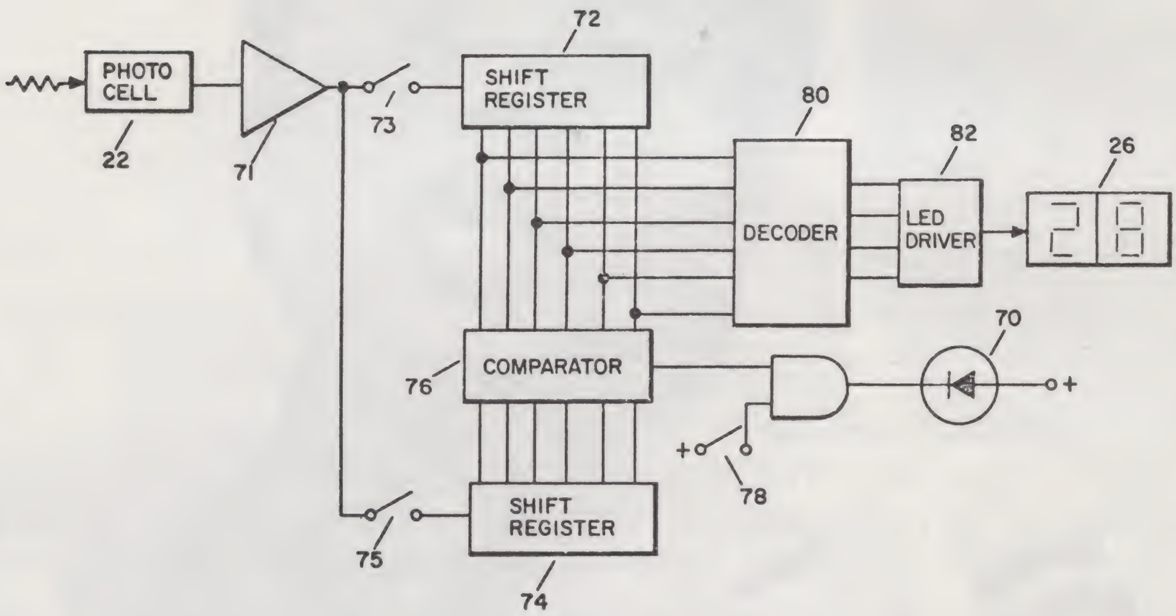


FIG. 2

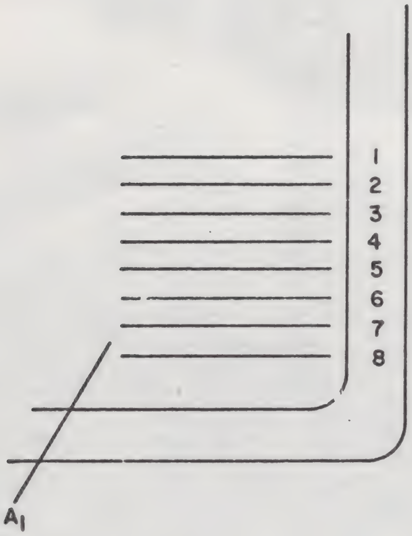


FIG. 3

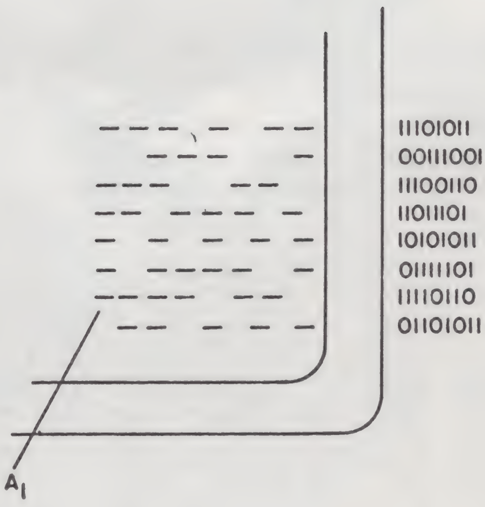
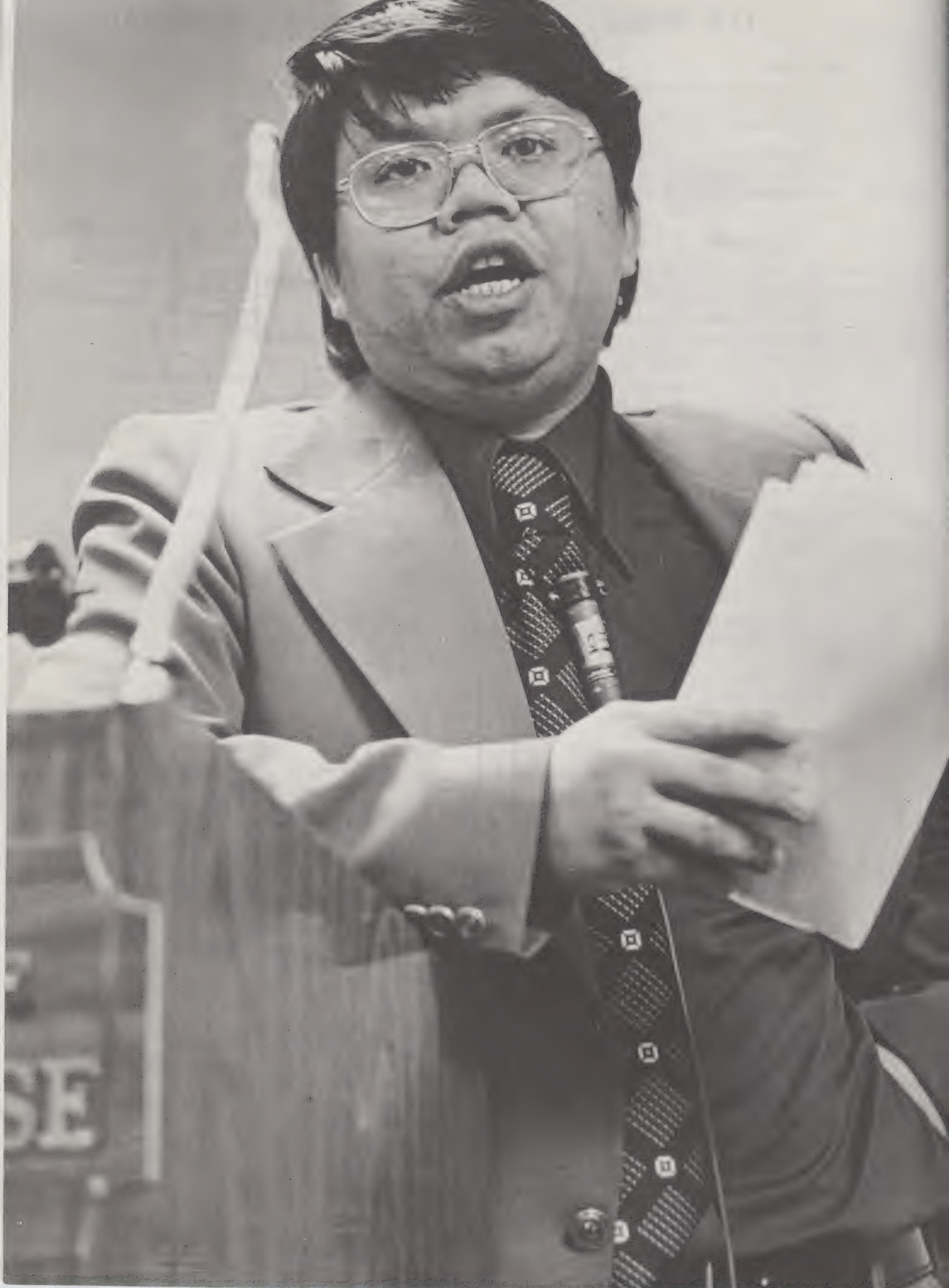


FIG. 4



AN APPROACH TO MICROPROCESSOR-BASED GAME ARCHITECTURE

Kam Li

Senior Staff Engineer

Signetics Corporation
811 East Arques Avenue
Sunnyvale, CA 94086

INTRODUCTION

With the introduction of microprocessors, the hardware implementation of electronic video games has undergone a radical change.

This paper describes an object-oriented approach to designing microprocessor-based video games. With this approach, all the picture generation, object updating, motion, and speed are controlled by the microprocessor. While the earlier random logic approach clearly works, it has several serious drawbacks that become particularly evident when compared with microprocessor-controlled systems. The most significant disadvantage is the tremendous amount of development time required to generate each new game, since an entirely new design is required for each different game. Furthermore, bugs that subsequently show up in the field can become a serious problem. This problem can be extremely difficult to correct, since all the boards must be recalled. When using microprocessors, this problem can be overcome, since software-controlled video games are easy to modify in the field.

Some of the advantages of microprocessor-based video games are summarized below:

1. Flexibility - Easy to Modify
2. Shorter Development Cycle - Development Time is Equivalent to Programming Time
3. Reliability - Fewer Parts Mean Fewer Repairs
4. Easier to Maintain - Problems can be fixed by simply Changing ROMs or PROMs.

Existing coin-operated, microprocessor-controlled games use a RAM-intensive (or RAM-mapping) approach. Figure 1 is a block diagram of the RAM-intensive approach. The RAM used may vary in size according to the resolution of the objects required. In this case,

Kam Li addressing audience at Gametronics.

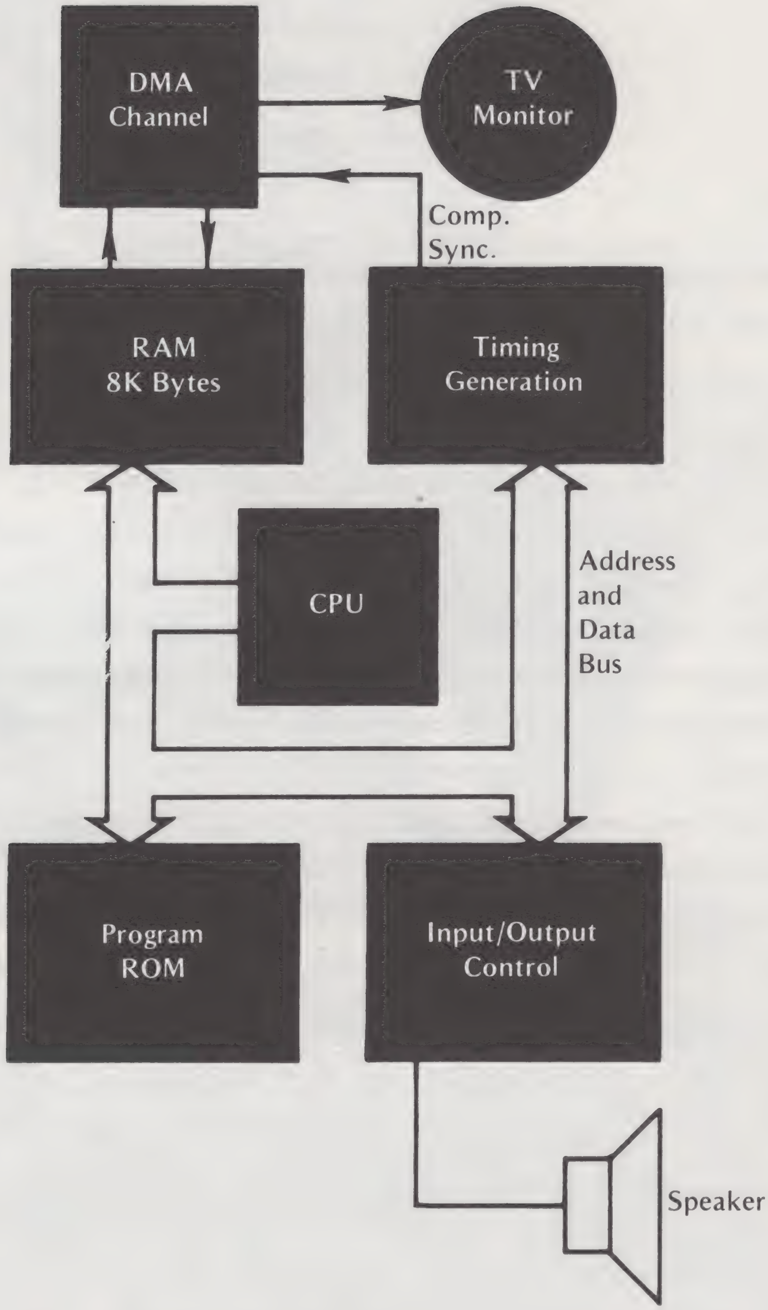


Figure 1 — Microprocessor-Controlled Video Game Using the RAM Intensive Approach

256 x 256 (65K) bits of RAM are used.

Video patterns, such as tanks, cowboys, and planes are permanently stored in ROMs. At the initialization of the program, these patterns of data are transferred from ROM memory and loaded into RAM memory where most of the data is stored throughout the game. The initial address in RAM, hence the initial position in which the image will appear, is fixed by the program. Consequently, the images will always appear in the same location each time the game is started. Some images (e.g., stationary images such as houses or trees) retain their initial address locations in RAM for as long as they appear on the screen and are simply read out each frame at the same location. Other images, such as submarines and tanks, are made movable by changing the location of the video patterns in RAM. This enables the position of these images on the CRT screen to change with successive frames or every other frame.

While vertical motion is relatively simple and only involves moving the block of image data up or down in memory, the actual mechanics of moving a complete video image up or down the CRT is more complex. Coherence and smoothness should be kept in all motions. Hence, each word in the block must move the same number of address units.

Horizontal motion is much more complex. Moving blocks of data alone will cause a jump from location to location. The correct action involves shifting each word into the next word. This avoids jerky and uneven motion (see Figure 2).

Games designed in this manner are fairly general puspose and can easily be adapted to other games by changing the programs. However, the bulk of the burden associated with block movement is placed on the processor, and the limiting factor is the number of moving objects that can be supervised by a microprocessor.

While the RAM-intensive approach works, it is costly and places a great deal of burden on the microprocessor.

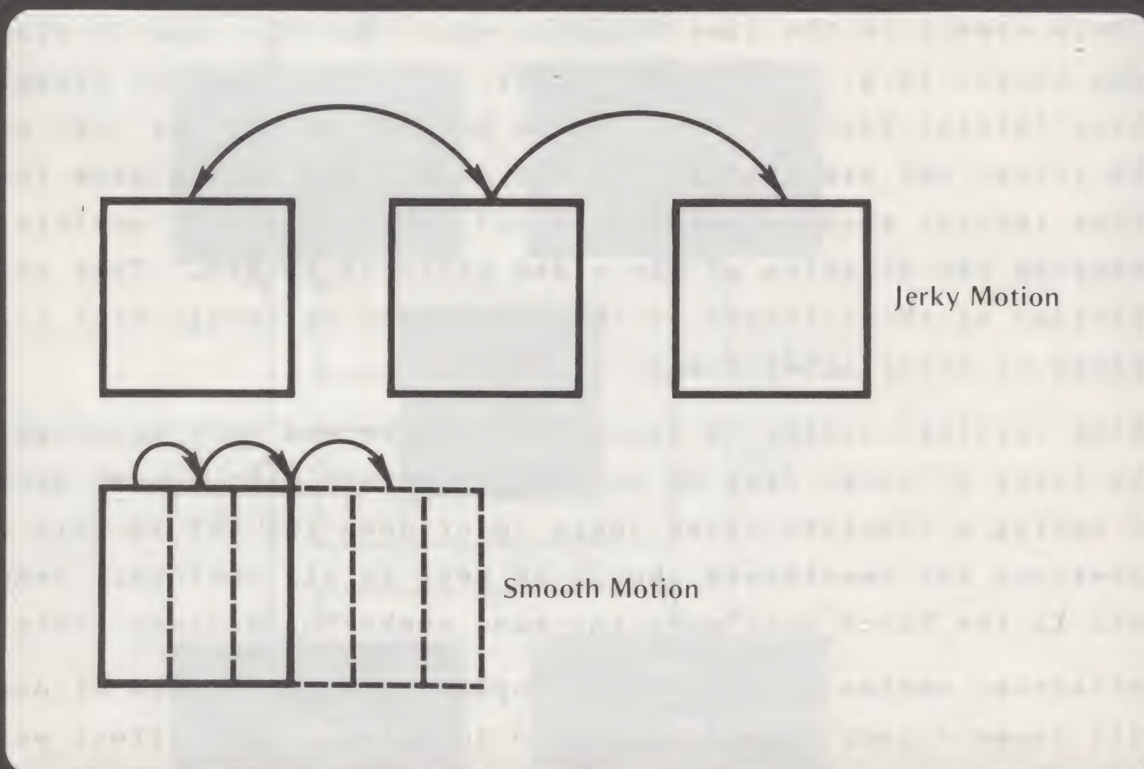


Figure 2 – A Comparison of Smooth and Jerky Motion

THE OBJECT-ORIENTED APPROACH

The object-oriented approach offers the following advantages:

1. More objects may be used and the motion of these objects is easier to control.
2. RAM requirements are minimal, thus reducing system cost.

Figure 3 is a block diagram of an object-oriented, microprocessor-controlled game system. The microprocessor reads the game stored in ROM and controls the video presented to the TV. The Object Blocks (OB) serve as a programmable video generator, interpreting microprocessor commands and presenting video to the Video Summer Block (VSB). The VSB accepts digital video signals from the object block and generates either RF for a standard TV Receiver or composite video for a TV monitor.

The microprocessor communicates with the OB over the address bus and data bus. Basically, the OB looks like part of the memory field to the microprocessor. The microprocessor writes data into the OB's RAM field. The OB, in turn, generates video that reflects the information stored in its control field. The OB also presents the 2650 microprocessor with I/O and status information (e.g., object collisions, etc.) by writing this data into its registers. The microprocessor can then read the I/O and status information data and make decisions accordingly.

To understand how the system operates, we will examine the functions of each individual block.

Timing and Sync Generation

All timing circuits are generated from a 3.58 MHz clock. The functions of these circuits are twofold:

1) To provide the various sync timings for the vertical and horizontal oscillations of the TV monitor.
2) To provide submultiples of the clock used in more complex signals bearing a synchronous relationship to the movements of the electron beam.

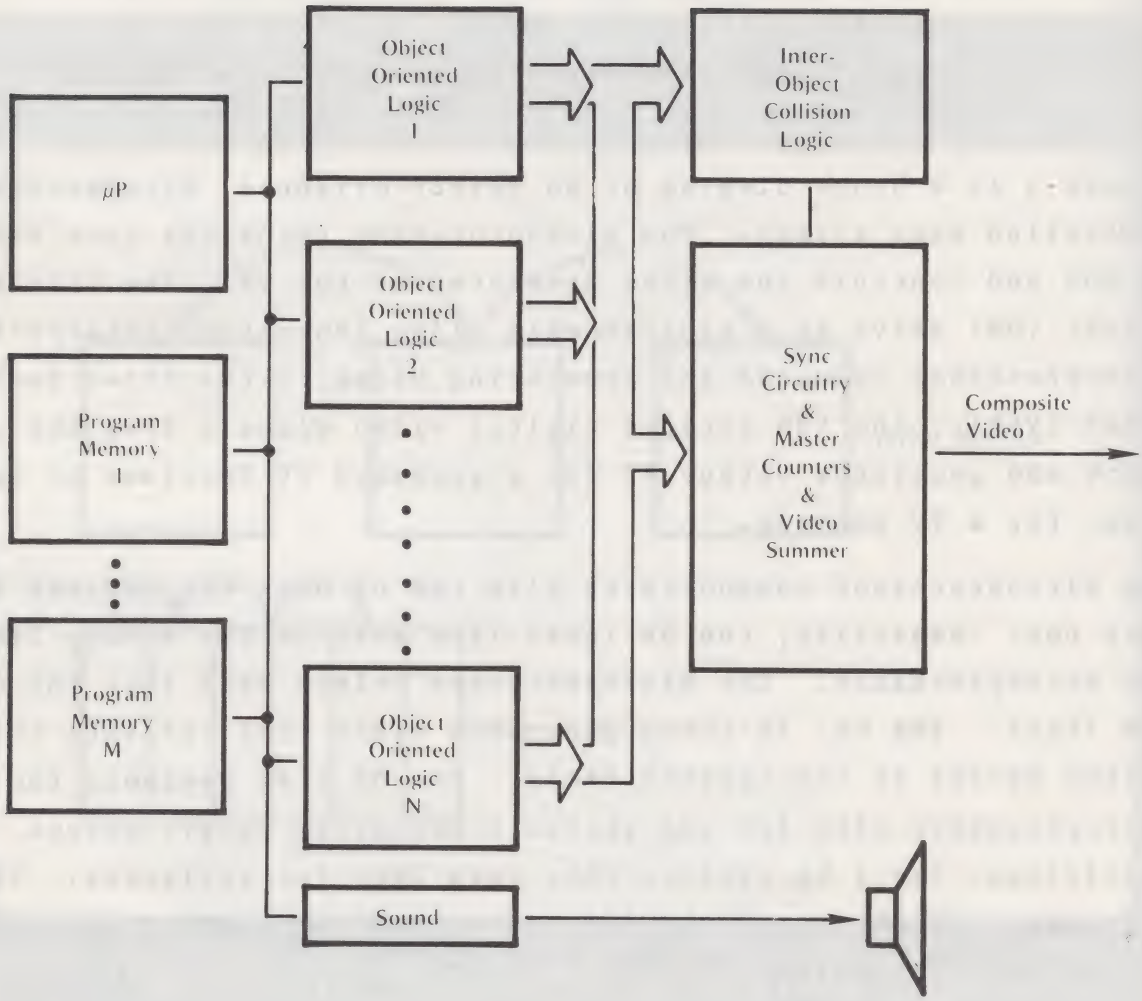


Figure 3 A Block Diagram of an Object Oriented Microprocessor Controlled Gain System

The timing chain is divided down as shown in Figure 4. The horizontal counter chain divides the frequency of the clock down to positions 1H, 2H, 4H ... 128H.

The vertical counter chain is identical to the horizontal chain except that it counts horizontal sync pulses rather than clock pulses. The divider chain also gives submultiples of vertical positions known as 1V, 2V, 4V ... 128V, as shown in Figure 4.

The two counters are used extensively throughout the system as described in subsequent sections.

Object Module Functions

A functional block diagram of each object module is illustrated in Figure 5. Each object module consists of:

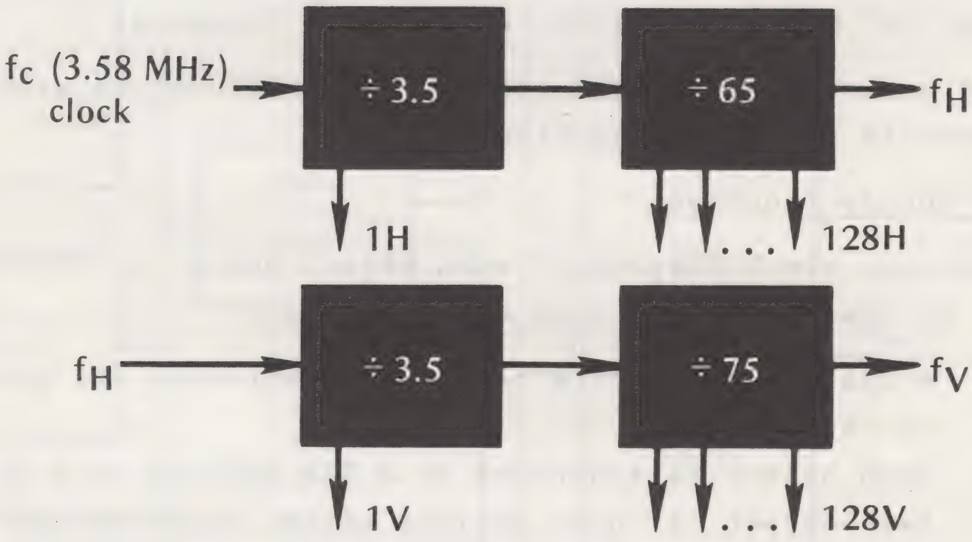
1) A pair of coordinate registers describing the position of the object.
2) Each object is described by a RAM pattern of m x n bits.
3) Each object can have various sizes, depending on the shifting rate controlled by the program.

The size and shifting rate relationship is tabulated as follows:

Shifting Rate	Object Size on a 25-inch Screen
280 nsec	0.8" x 0.6"
560 nsec	1.6" x 1.2"
1120 nsec	3.2" x 2.4"
2240 nsec	6.4" x 4.8"
4480 nsec	12.8" x 9.6"

The object module operates as follows: The pair of coordinate registers specifies the location where the object is to be shifted out. A set of master counters and vertical and horizontal counters is available from the sync block to indicate where the electron beam is at a given instant. When the coordinate registers match the master counters, the object pattern is shifted out.

The size of the object can be controlled by controlling the shifting rate of each object. The resolution is controlled by the size of the pattern. A finer object can be painted by a bigger pattern.



f_H = horizontal sync frequency

f_V = vertical sync frequency

f_C = color frequency

Figure 4 — Vertical and Horizontal Counter Chain

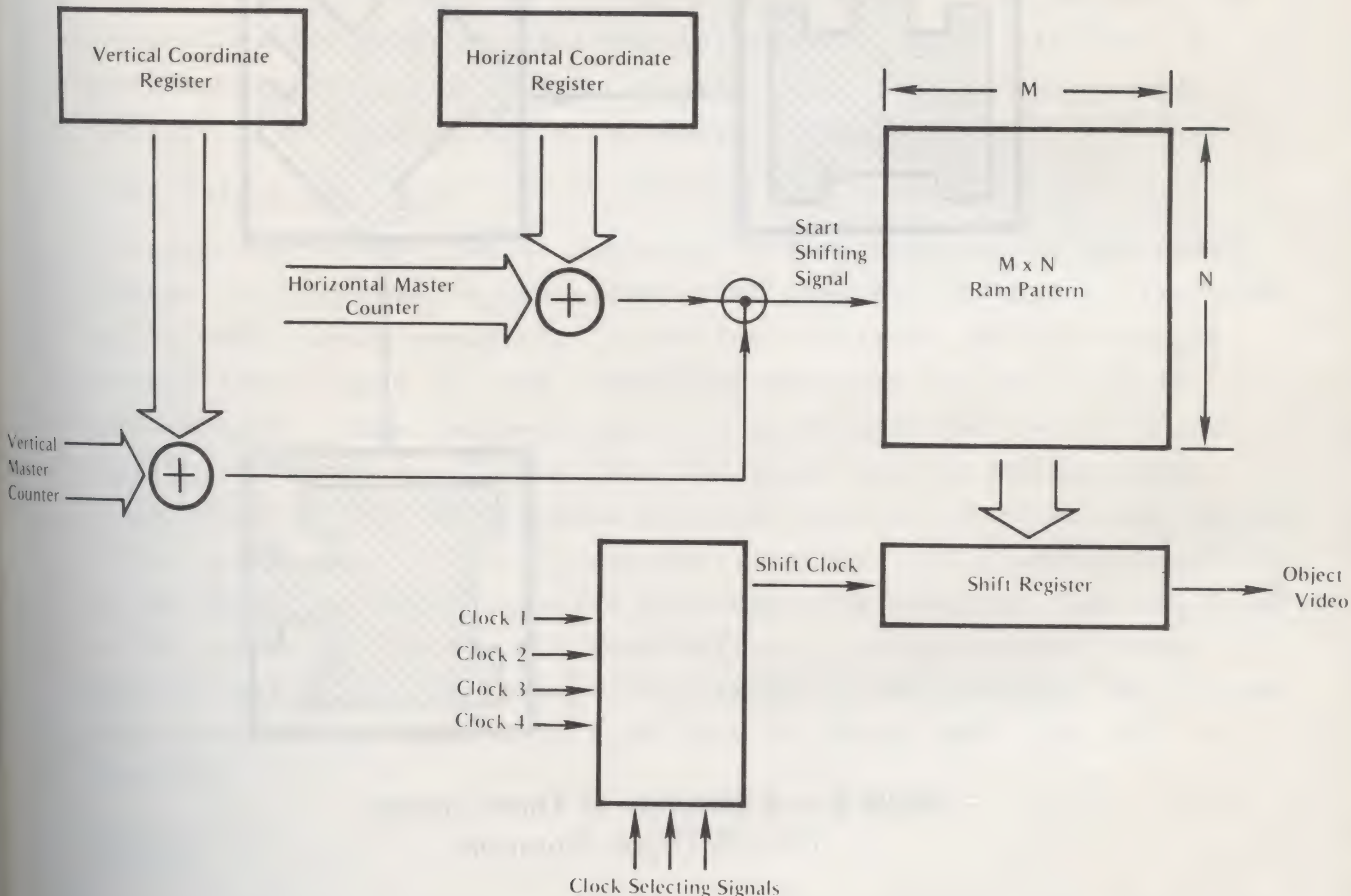


Figure 5 Object Module Block Diagram

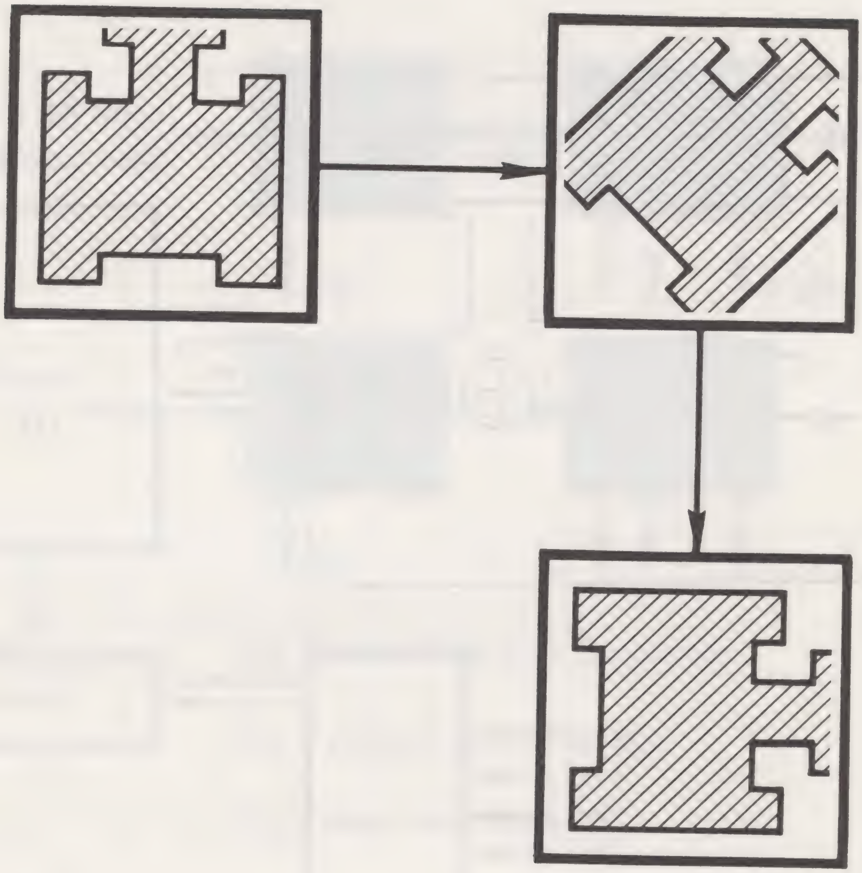


Figure 6 — A Sequence of Three Patterns
for a 90 Degree Rotation

Movement of objects can be achieved by programming the microprocessor to change the coordinate register pair of the objects. Vertical motion can be achieved by incrementing or decrementing the vertical coordinate register. Horizontal motion is accomplished by incrementing or decrementing the horizontal coordinate. In this way, two degrees of freedom are available to each object. Other motions, such as rotation, are accomplished by more complex means. For example, an automobile with rotation will involve several object patterns at different angles. A 90-degree rotation will involve successive displays of several patterns as shown in Figure 6.

Inter-Object Collision

Collision of objects can be detected by both hardware or software. However, in the case of non-symmetrical objects, no unified algorithm can be effectively employed. Detecting collision can be a lengthy process (see Figure 7), and a hardware approach is used in this architecture. This hardware approach is illustrated in the block diagram of Figure 8. Coming into the block are 'n' object video signals indicating the presence of each object. To detect all inter-object collisions, it would take $(n-1)!$ gates. As n approaches 8 or 9, the amount of logic required explodes. In practice, not all inter-object collision signals are required; e.g., a cactus will never collide with a home in a game. By assigning and grouping the objects effectively, a minimum of inter-object collision detection is required.

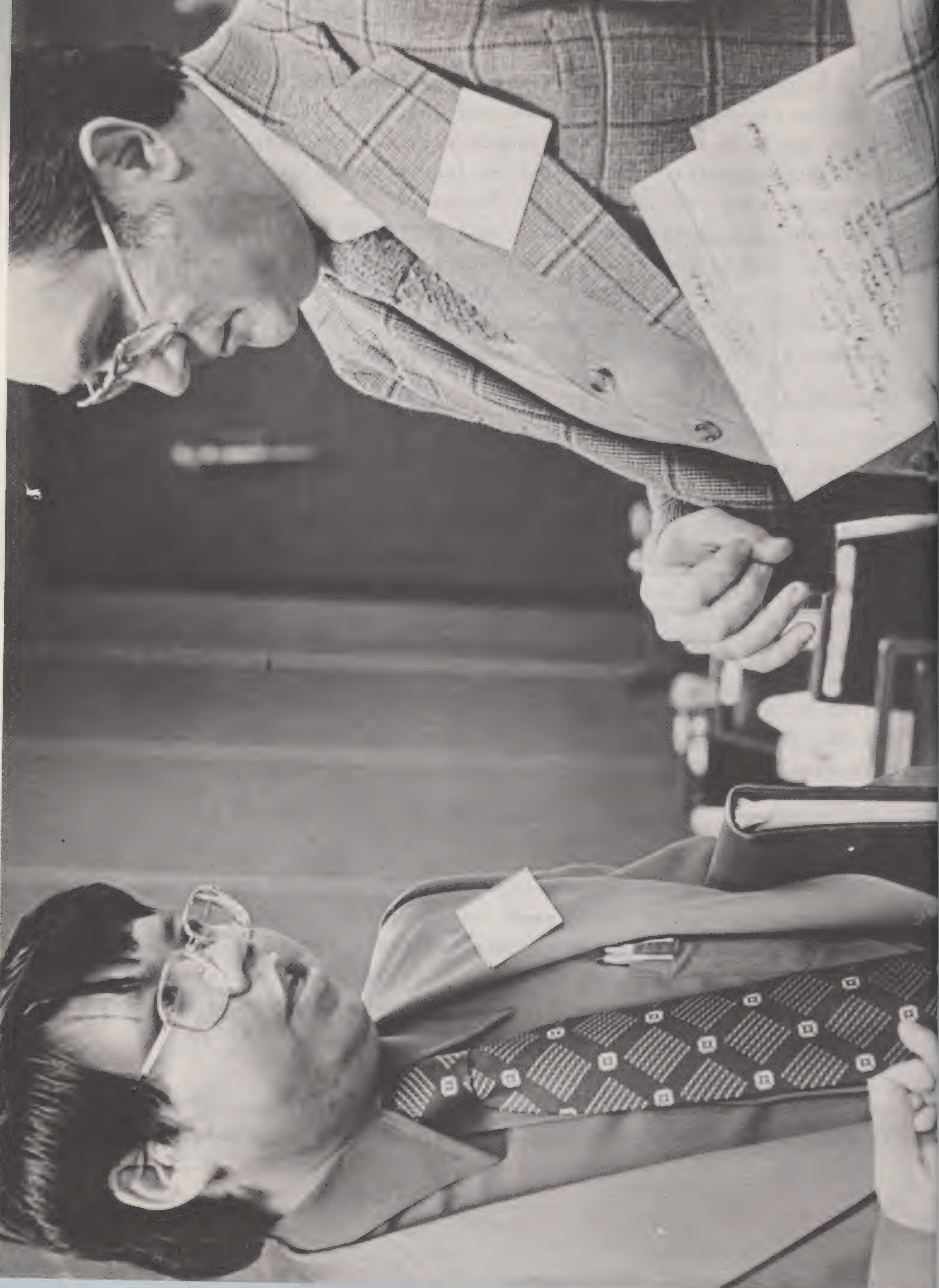
SUMMARY

A major feature in using an object-oriented approach to implementing microprocessor -based video games is flexibility. With this approach, games may be changed simply by changing the program. Furthermore, the level of complexity or degree of sophistication of the games can be varied by simply adding on the appropriate units of object modules.

The plug-in modules, in this case, can be:

1) Programmed ROMs for different games
2) Object modules for varying levels of complexity of games

Another feature of this approach is that the same system may be used



for other standards (e.g., Phase Alternating Lines -- PAL) simply by replacing the sync and color block.

Li with Charles Leicht of the Ideal Toy Corporation.

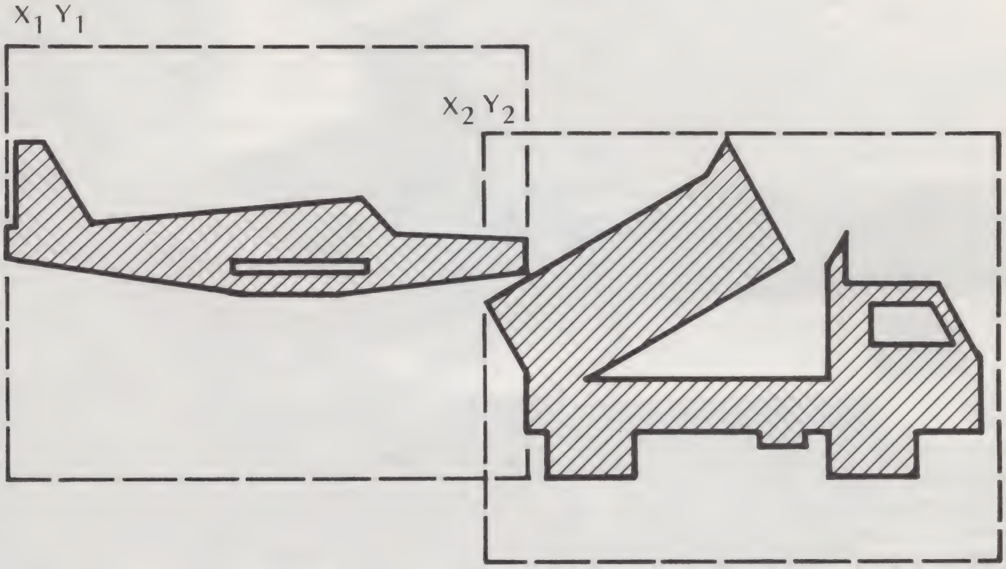


Figure 7 Collision of Non - Symmetrical Objects

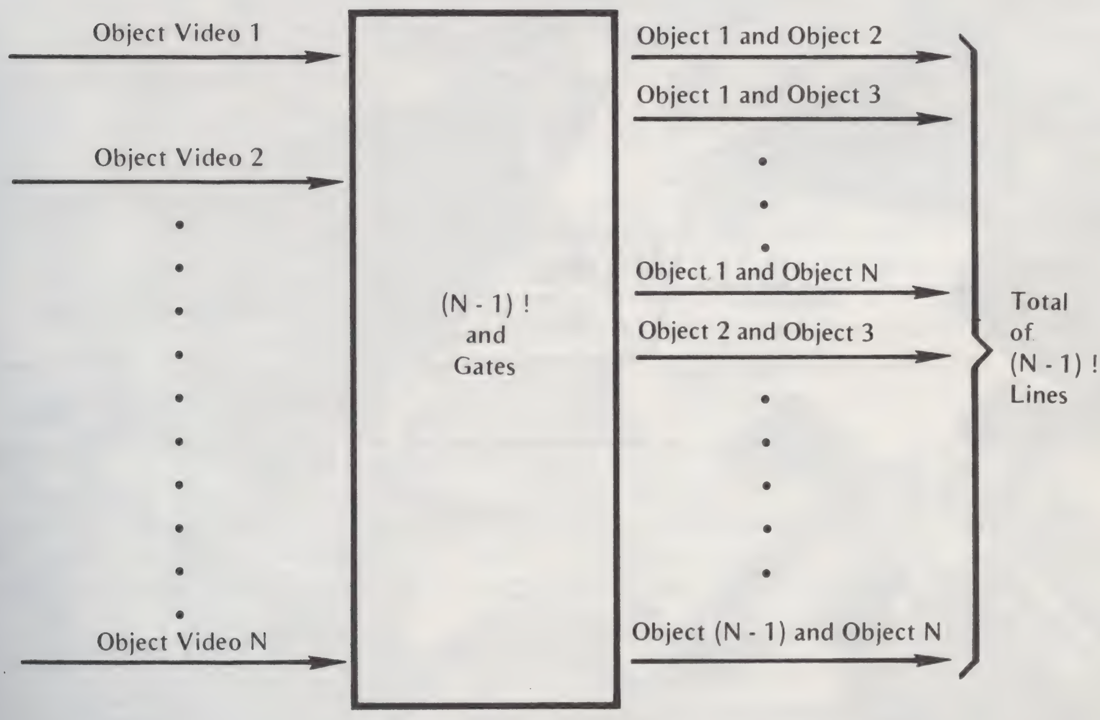


Figure 8 Inter-object Collision Detection

III. APPLYING THE F8 MICROCOMPUTER FAMILY TO GAMES

RONALD L. BALDRIDGE
Applications Engineer
MOSTEK Corporation
Irvine, California

Game playing computers have been around for a long time but only recently has the phenomenon really fired the imagination of both game manufacturers and the general public. Much of the credit for this must be given to this decade's most revolutionary electronics development: the microcomputer. For the first time cost effective intelligent games can be designed containing the game algorithim in "firmware" within a microcomputer consisting of only a few integrated circuits inside the game apparatus.

Why Use a Microcomputer?

Asking "Why use a microcomputer for games? is like asking why use transistors instead of tubes for TV's. The answer applies not only to games but to a myriad of other electronics applications from vending machines to consumer appliances formerly using relays and TTL logic. First let's consider the design goals for games summarized in Fig. 1.

Design Goals for Games

A new game must be entertaining to be played or purchased by the consumer. To prevent rapid boredom the game should therefore require a challenging degree of skill and sophistication on the part of the player. The flexibility and power of the microcomputer permits this sophistication to be included within the microcomputer program or firmware.

Secondly, the game needs to be low cost to justify its purchase or play. The bulk of the cost as we will see is the games production cost, and this is where the microcomputer really shines, by lowering the number of IC's required to implement a design. This reduction in components also helps fulfill the other game design goals of increased reliability and ease of manufacture.

One of the most important goals, that of flexibility, is achieved by having the game in firmware. Making design changes or creating new designs then becomes a matter of changing the firmware, usually a ROM or PROM plugged into a socket within the game electronics - the hardware remains the same.

Microcomputer Design Advantages

The advantages of using a microcomputer to achieve these design goals for games are summarized in Fig. 2. As in the case

---

NBC newscaster Jack Bates interviews Dr. David Chandler and Ron Baldridge.

ENTERTAINING - Sophistication and Skill

LOW COST - Product cost, Recurring Engineering

EASY TO MANUFACTURE IN VOLUME

EASY TO SERVICE - Self-diagnostic Capability

FLEXIBLE - Design Changes
New Designs
Game Options (Difficulty factor)
(Number of Players)
(Coins, etc)

RELIABLE - Low Down Time

FIG. 1 DESIGN GOALS FOR GAMES

LOWERS COST
Development, Production, Recurring Engineering

REDUCES COMPONENTS
Firmware replaces hardware
Fewer PC boards, holes, solder connections, sockets connectors, wiring, support circuits
Less power, heat dissipation
Simpler packaging, assembly, spare parts inventory, purchasing overhead, maintenance

INCREASES FLEXIBILITY
Firmware easier to change than hardware
Sophistication and intelligence is function of firmware

LOWERS COST OF NEW DESIGN
Basic hardware designed
Reuseable software subroutines

SIMPLIFIES DESIGN CHANGES
Change "firmware" (ROM/PROM) rather than hardware

SIMPLIFIES MAINTENANCE
Self-diagnostic testing
Increased reliability

FIG. 2 MICROCOMPUTER DESIGN ADVANTAGES

of replacing the tube by the transistor for TV's, we can see that there are almost no trade-offs to be made in using microcomputers. Designs are at the same time lower in cost, more flexible, more reliable, use less power and fewer components and are simpler to manufacture and maintain.

Now that the game designer is convinced that a microcomputer will improve a new design in almost every category, one is still faced with the problem of selecting the best device to meet the design goals among the wide variety of devices available. To determine the most important characteristics is not always easy, but generally involves a weighting of the following:

Cost
Availability (second source?)
Input/Output Capability
Memory Size
Instruction set
Speed
Power
Interrupts
Reliability
Supplier Reputation
Temperature range

<u>The MOSTEK F8 - Ideal for Games</u>

The MOSTEK F8 microcomputer family has unique architecture and performance features that make it ideally suited to meeting the most important requirement for games - namely good performance at low cost in volume. Many of these important characteristics are summarized by Fig. 3.

The current family of MOSTEK F8 parts consist of the following:

MK3850 - CPU (Central Processing Unit) with 16 bits of I/O, 64 byte scratchpad, internal reset and oscillator circuitry.

MK3851 - PSU (Program Storage Unit) with 16 bits of I/O, 1K ROM, programmable timer, and external interrupt.

MK3853 - SMI (Static Memory Interface) interfaces the CPU to up to 65K of static memory, ROM, RAM or PROM. Also has programmable timer. Used to expand memory.

MK3852 - DMI (Dynamic Memory Interface) interfaces the CPU with up to 65K of static <u>or</u> dynamic memory. Contains dynamic memory refresh circuitry and automatically controls MK3854 DMA chip. Used to expand memory.

MK3854 - DMA (Direct Memory Interface) permits transparent DMA up to 500K bytes/sec. Used for high speed data transfers.

MOSTEK F8 FAMILY - IDEAL FOR GAMES

LOW COST

- plastic package (15% less than ceramic)
- low power dissipation
- SDB/AIM development system

UNIQUE ARCHITECTURE

- high level of integration
- on-chip RAM, ROM, I/O, Timer
- fewer components required, 1 or 2 chip system
- less support circuitry required

FLEXIBLE

- 65K Memory (PROM, ROM, RAM - dynamic or static)
- 256 Input/Output ports
- Transparent DMA
- Complete family for 1, 2 or multichip systems

HIGH PERFORMANCE

- N-channel silicon gate
- 2 microsecond instruction time
- 70 basic instructions

FIG. 3 KEY FEATURES OF MOSTEK F8 FAMILY

MK3861 - PIO (Parallel Input/Output) contains 16 bits of I/O, programmable timer, and external interrupt. Used to expand I/O.

Two new devices being introduced are:

MK3870 - a new +5v only, single chip microcomputer containing 2K ROM, 64 byte RAM, 32 bits of I/O, on board reset and oscillator circuitry, external interrupt, and enhanced programmable timer, all in 40 pin package for under $10!

Mk3871 - PIO (Parallel Input/Output) a new PIO device containing the new timer design and interrupt logic featured in the MK3870 for use in the 3850 series.

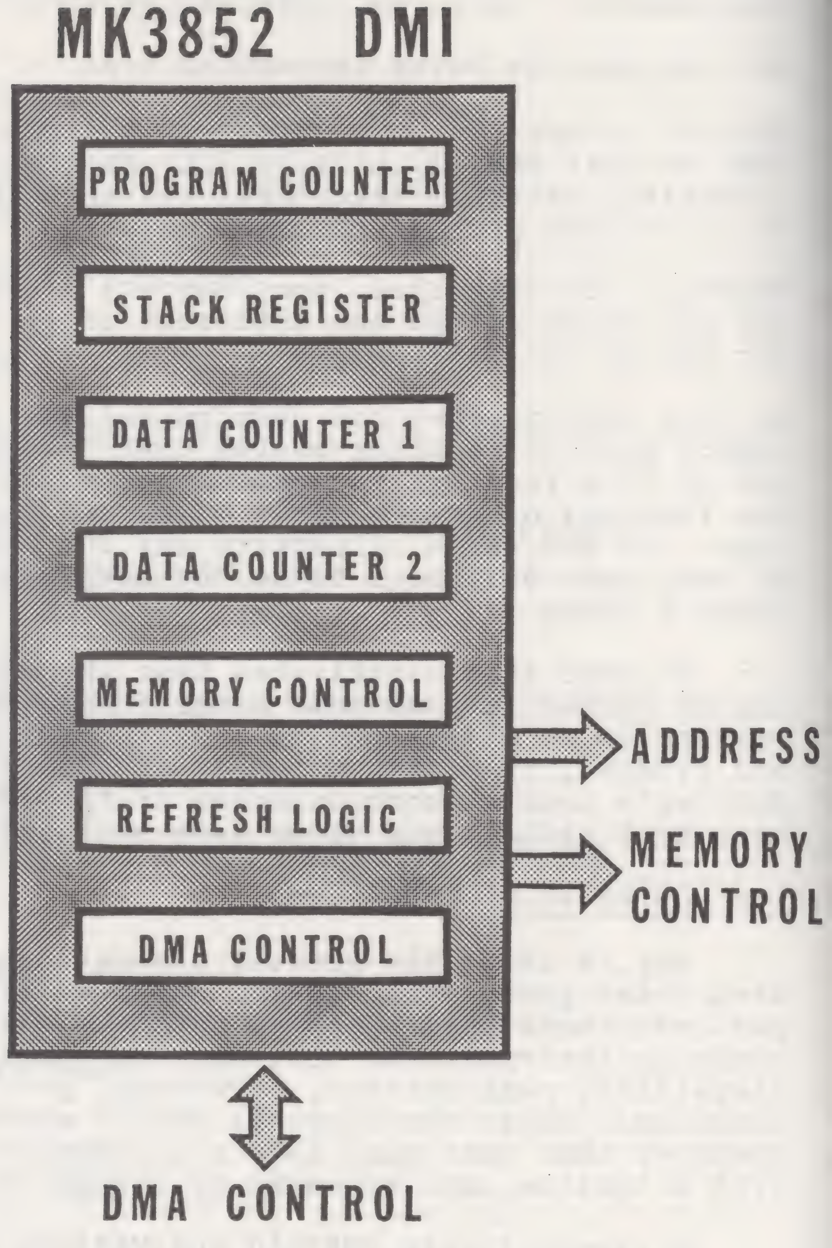
As this family grows, new devices will appear all aimed toward the common goal of reducing system cost through minimizing the number of IC's required to implement a given design. Some of the key features of the F8 parts discussed above are highlighted in Figs. 4-8 and again illustrate why the MOSTEK F8 is considered by many game designers to be the best microprocessor choice for today's games.

We have thus established that the microcomputer is the only way to go for serious game designs and that the MOSTEK F8 represents an excellent choice of combining economy, performance, and flexibility within a family of readily available parts. Now let's look at some examples of this F8 family in action spanning both pinball and video game applications.

The MOSTEK F8 in Video Games

Fig. 9 shows the general elements required in a coin actuated video game. The central computer determines that the proper coins have been inserted into the coin acceptor then proceeds to interpret the operators manipulation of the controls (joysticks, push buttons, keyboards, pots, etc.) and supply sound and update the displays and TV monitor when required. The computer thus acts much like a transducer in converting the control actuation into movement or changes on the video monitor.

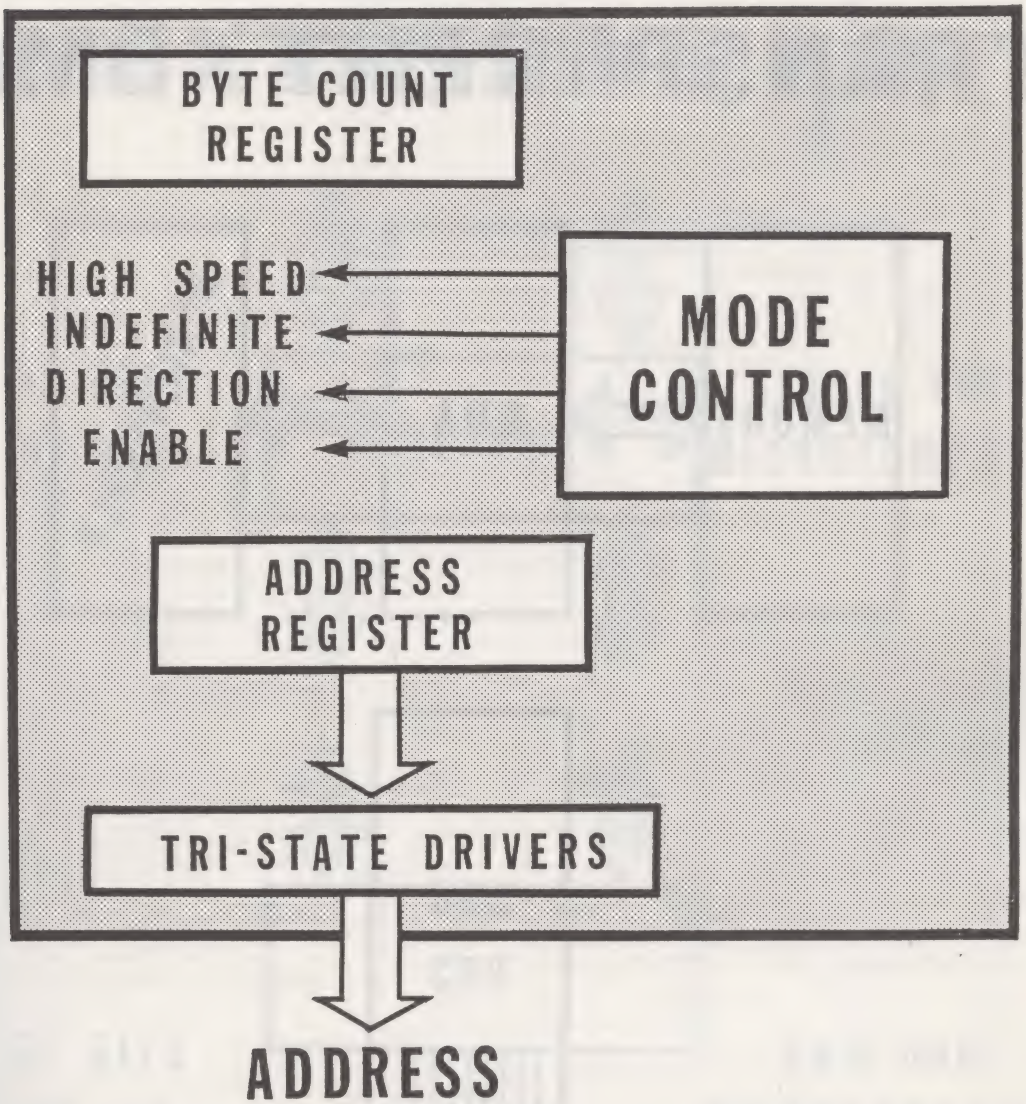
A simple 2 chip (MK3850 and MK3851) F8 based, paddle type video game developed by a European company is shown in Fig. 10. The video display is refreshed out of a 4K x 4 memory (four MOSTEK MK4096 dynamic RAM's) and this act of display refresh also refreshes the dynamic RAM's. The output of the memory goes to a video shift register where it is converted from parallel to a serial train of binary data to be fed into a video summer circuit. The horizontal and vertical address counters provide a 128 x 128 format and normally address the memory except during those times when the F8 CPU switches the multiplexers to supply its own memory address. The writing of a single bit into the



- ☐ ADDRESSES 65K STATIC OR DYNAMIC MEMORY
- ☐ AUTOMATICALLY CONTROLS REFRESH OF DYNAMIC MEMORY

FIG. 4 - MK3852 DYNAMIC MEMORY INTERFACE

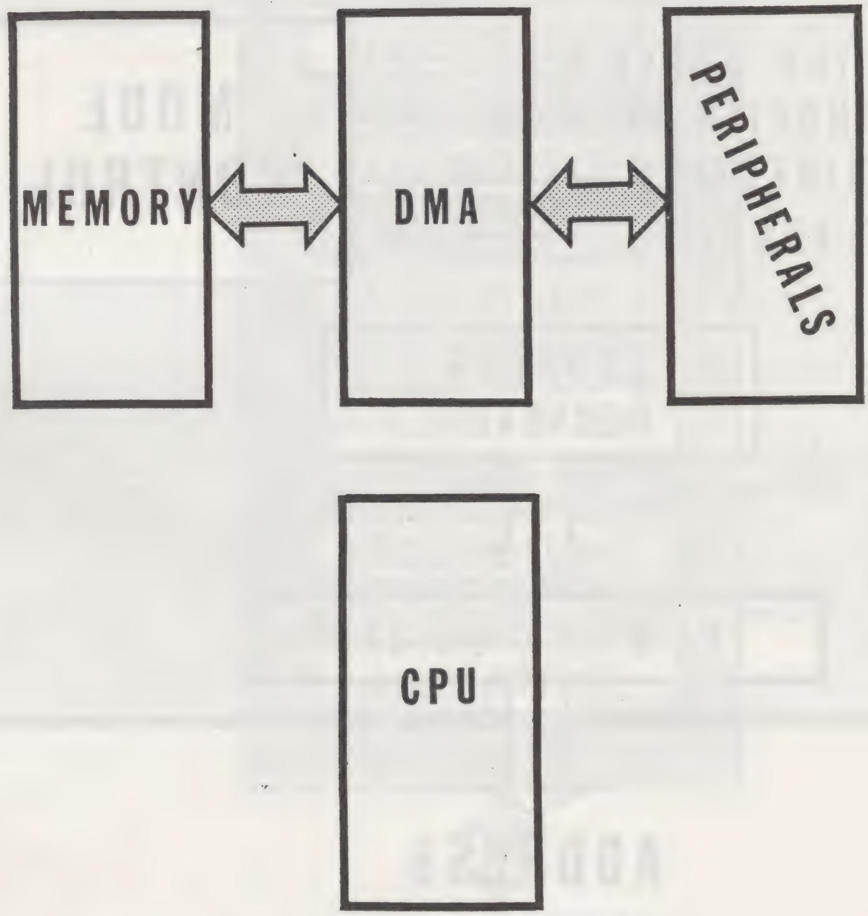
MK3854 DMA



- SOFTWARE CONTROLLED
- CONNECTS DIRECTLY TO ADDRESS BUS

FIG. 5 - MK3854 DIRECT MEMORY ACCESS

TRANSPARENT DMA



500 K BYTES/SECOND

NO CPU THROUGHPUT DEGRADATION !

FIG. 6 - KEY FEATURE - F8 DMA IS TRANSPARENT

EXTENSIVE I/O

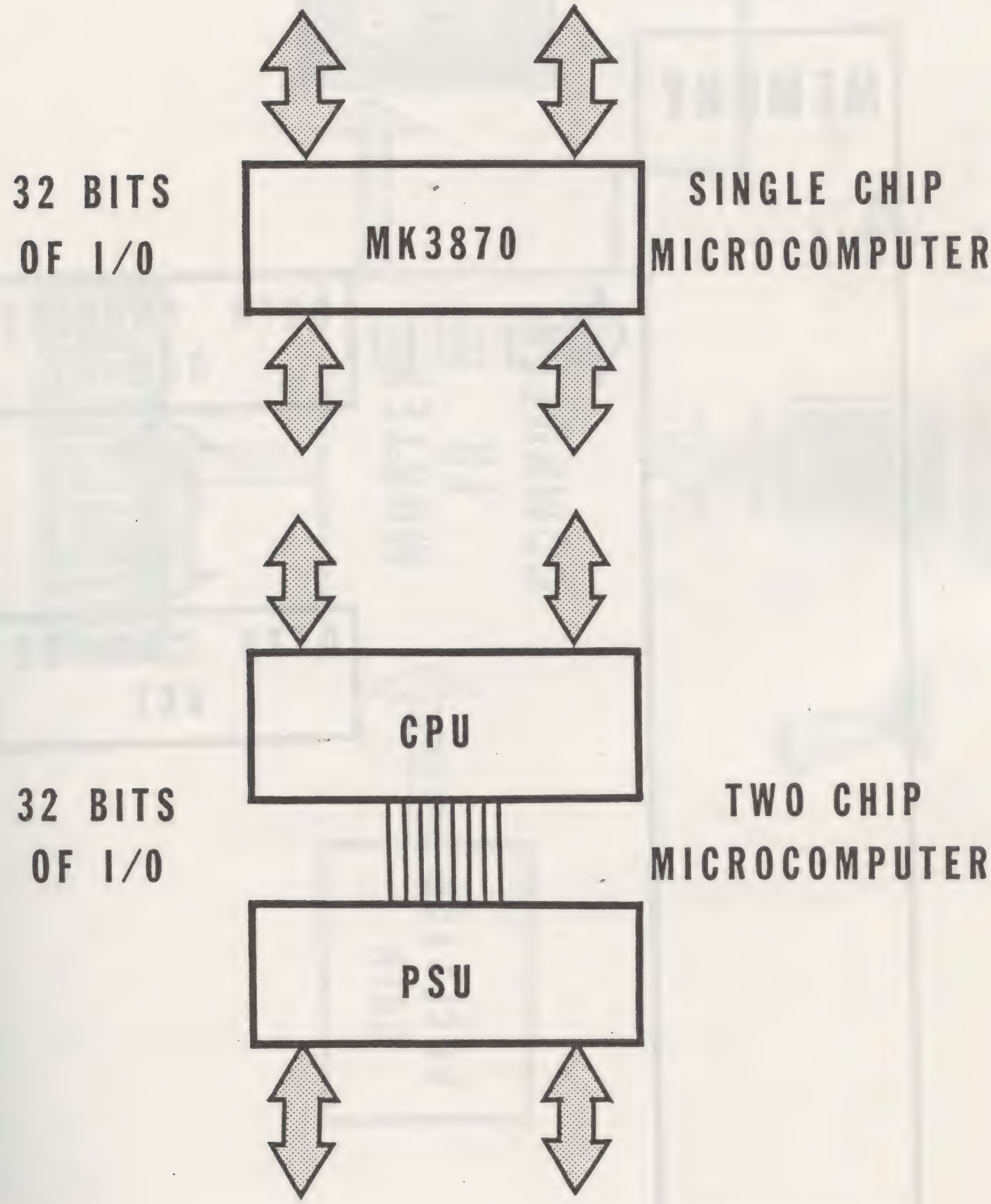


FIG. 7 - KEY FEATURE - F8 IS I/O INTENSIVE

MULTIPLE INDIRECT MEMORY ADDRESSING REGISTERS

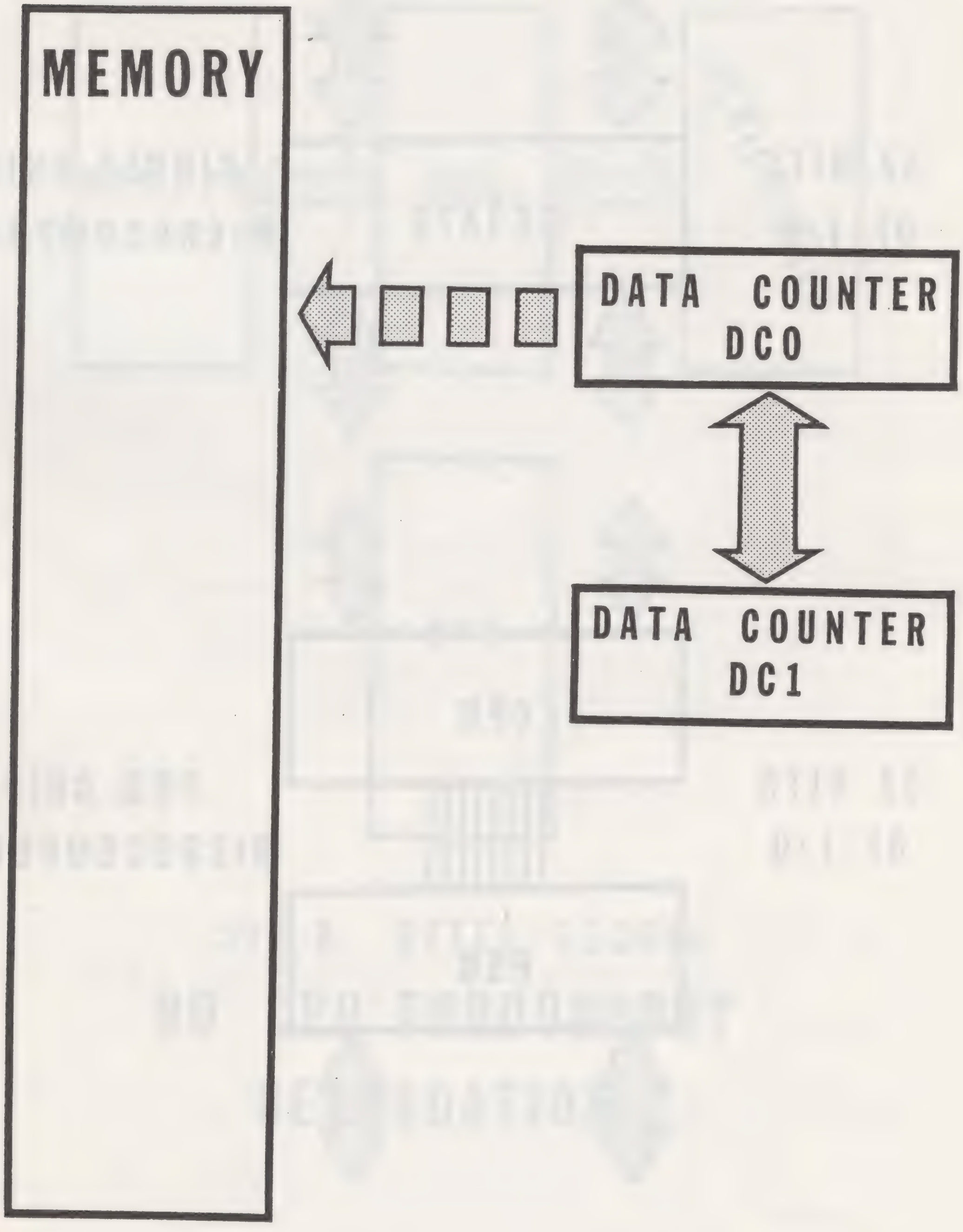


FIG. 8 - KEY FEATURE - F8 ARCHITECTURE PERMITS EASY DATA MOVEMENT BY MAINTAINING TWO DATA COUNTERS

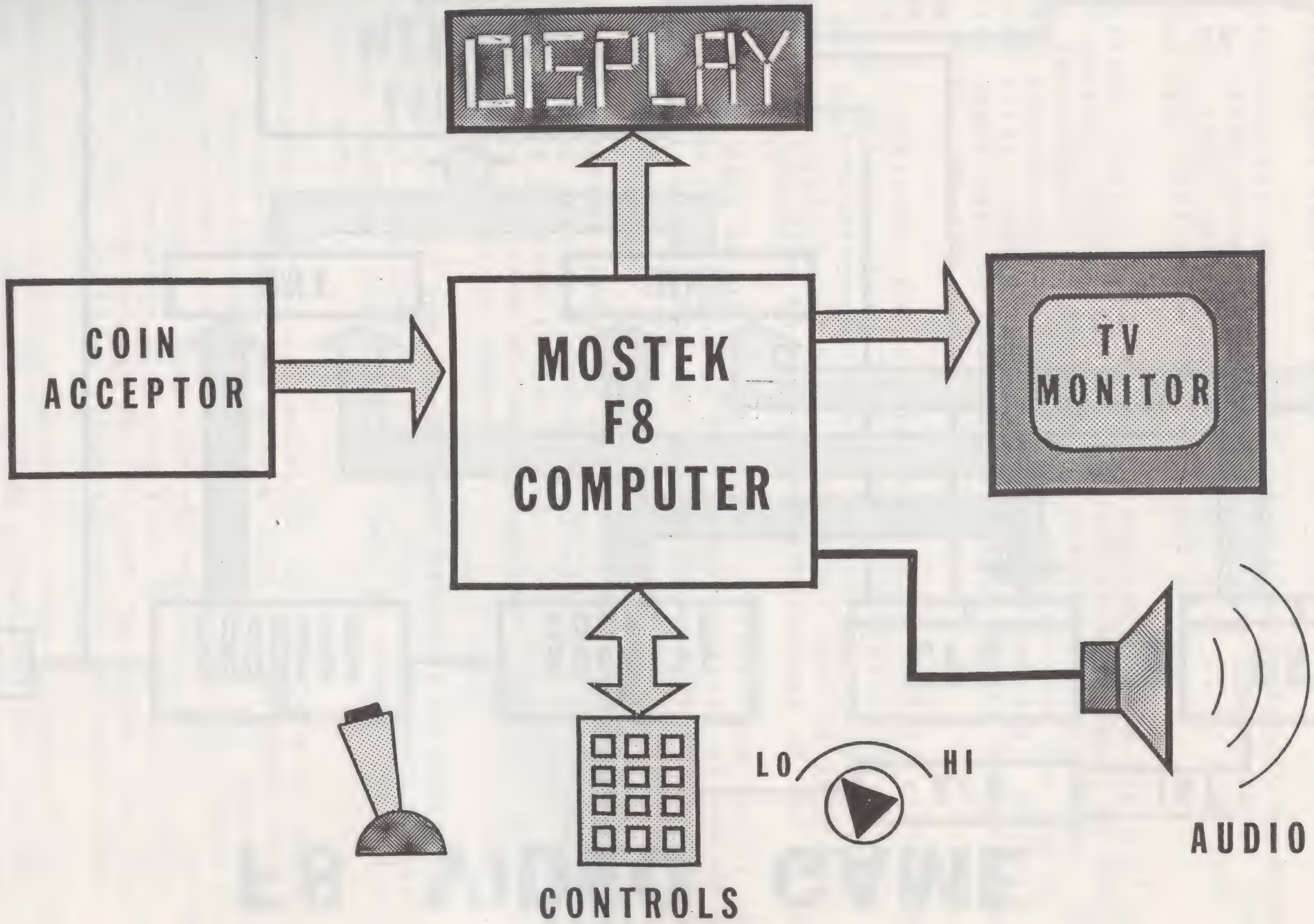


FIG. 9 - GENERAL VIDEO GAME ELEMENTS

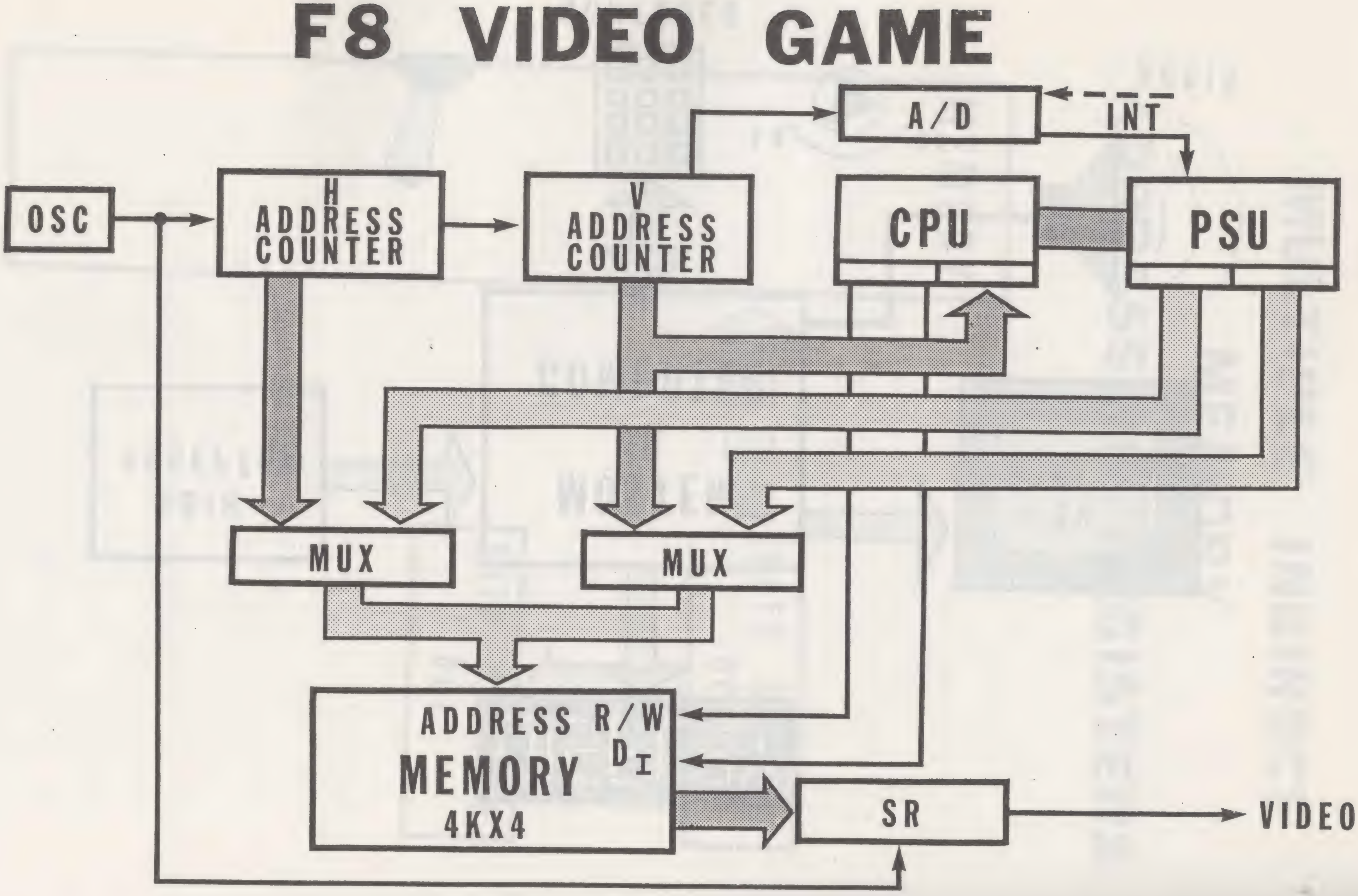


FIG. 10 - MOSTEK F8 BASED VIDEO "PADDLE" GAME

memory can thus be accomplished concurrently with display refresh. To the programmer then, the memory is organized as 16K x 1.

Analog/Digital conversion of potentiometer inputs is accomplished by firing a one-shot at vertical line number zero. When the one-shot times out, the number of vertical lines displayed since line zero will be in the CPU input port.

Vertical retrace is detected by monitoring the state of the vertical address counter and may be used as the signal to begin changing the elements of the display before the next frame. By processing rapidly moving objects and objects near the top of the screen first, some slight jitter may be avoided. Object distortion might also be reduced by writing in the new position before erasing the old.

Fig. 11 outlines the features of a more sophisticated video game called Tank Squadron. This game illustrates the use of the F8 DMA feature discussed above, to provide maximum flexibility and performance and also illustrates how one goes from prototype to production to take maximum advantage of the F8 family.

The block diagram of the prototype of Tank Squadron is shown in Fig. 12. The F8 portion of the system consists of the MK3850 CPU, MK3861 PIO, MK3852 DMI and MK3854 DMA. A brief description of the systems operation follows.

The information appearing on the screen is divided into the fixed background pattern (bombed out buildings, trees and shrubs) and the variable pattern (tanks, mines, shells, score). These two patterns are switched at the appropriate time by a multiplexer going to the video summer.

The playing field ROM (background pattern) is addressed continuously and converted to serial data at the multiplexer. Common video packing techniques are used to reduce the ROM size (½K in this example).

The variable pattern is contained in RAM (1K x 8) where it is read out by the MK3854 DMA device into a high speed FIFO (16K x 8). The Field Select circuitry compares the contents of the FIFO against the horizontal position to determine when to switch the multiplexer to read out the variable field. The horizontal position circuitry also provides the vertical retrace signal back to the F8 through an I/O port to signal the start of the variable field update as required before the next frame.

The initial or starting patterns of the variable field objects are obtained from a 3K x 8 ROM addressable by the CPU. This contains tank positions, mine and shell patterns as well as constant score patterns.

TANK SQUADRON

Designed by Chandler Business Machines for Video Play International Corporation

FEATURES

- 2 or 4 players with 1 joystick per player
- Realistic battlefield simulating bombed buildings, trees, and shrubs
- 16 tank orientations – tank explodes when hit
- Right, left, forward, reverse control
- 16 land mines – explode when hit
- Teamplay with 4 tanks
- Separate fire control for each tank – range 1/3 screen
- Automatic score keeping on screen –score reduction when tank is hit
- Tank sound varies with tank acceleration

FIG. 10 - FEATURES OF F8 BASED TANK GAME

TANK SQUADRON PROTOTYPE

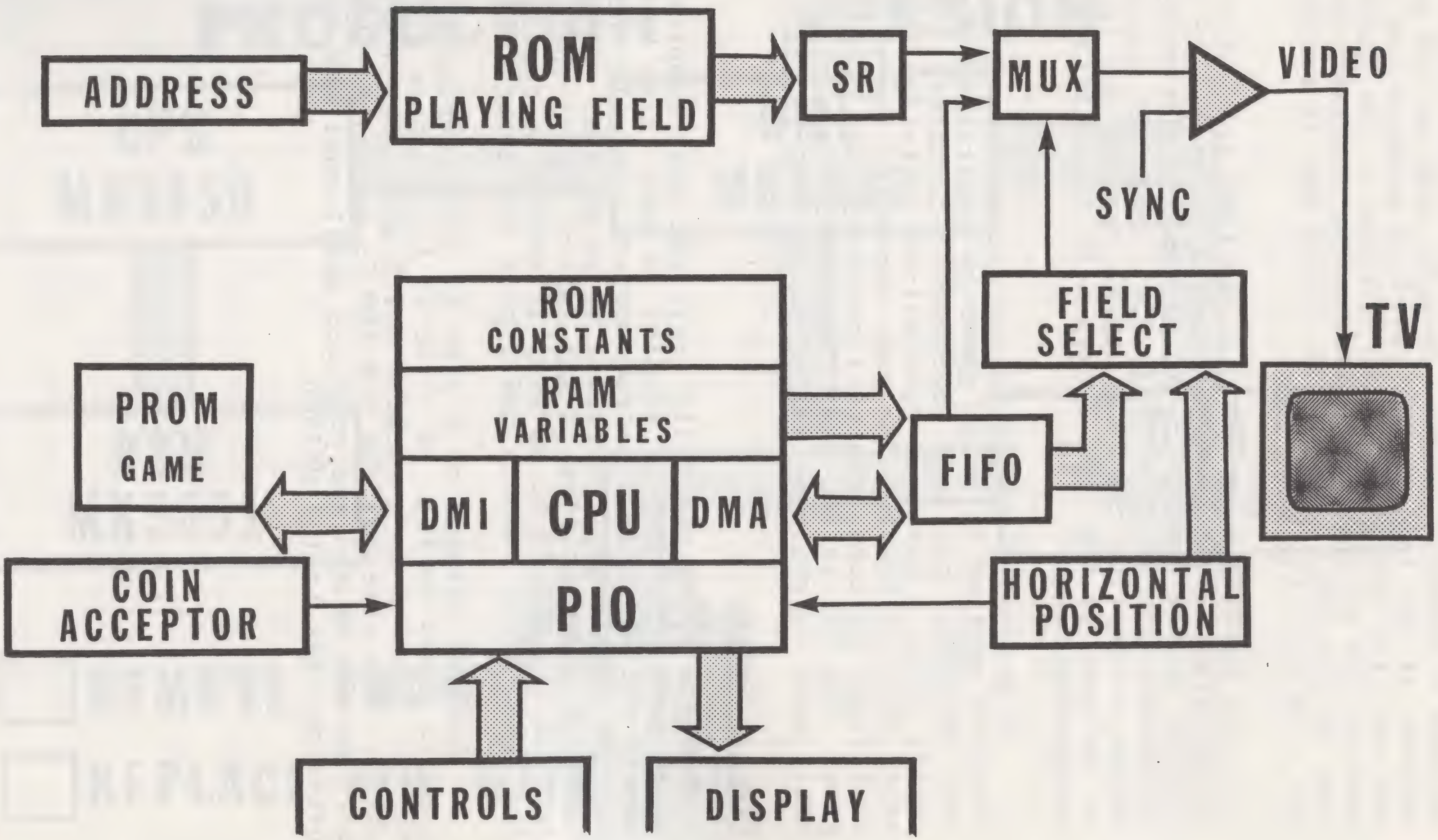


FIG. 12 - TANK SQUADRON PROTOTYPE

Right, left, forward and reverse tank motions are handled through a joystick control brought into an I/O port. Push buttons at the top of each joystick provide the tank fire control and are also brought into an I/O port. The audio and attention getting LED flashers are produced by firmware through an I/O port on the CPU. All in all, 20 of the 32 available I/O bits are used for this tank game.

The prototype version of the tank game uses PROM to store the program. This permits changes to be easily made while field testing before committing to the masked ROM MK3851 PSU used in the production version (Fig. 13). When the system is ready for volume production the PROM can be removed and the MK3861 PIO can be replaced in the same socket with the MK3851 PSU to reduce production cost.

An extension of the design approach used in Tank Squadron could be applied to other games by separating the electronics into game dependent and game independent circuitry. Fig. 14, for example, shows a possible generalized cartridge based game design using this approach. The game dependent cartridge contains the background pattern, constant patterns, and game program for each game. The PSU in the game independent section may contain commonly used subroutines called by the PSU in the cartridge.

Pinball Games

These games generally represent less complexity than the video game hence may be handled in many cases by a single chip - namely the new MK3870 microcomputer. Fig. 15 shows a pinball machine completely controlled by an MK3870. Common inexpensive decoders and multiplexers may easily expand the 32 I/O bits present on the MK3870 to as many as needed to operate 7-segment displays, drive bumpers and lights and detect ball paths.

Another example of a game of less complexity than the video game is shown in Fig. 16 - the F8 based chess playing computer. MK3870, results in a machine which will play a credible game of chess. The external 256 x 8 RAM is addressed through an I/O port on the MK3870 and provides additional RAM beyond the 64 bytes already in the MK3870.

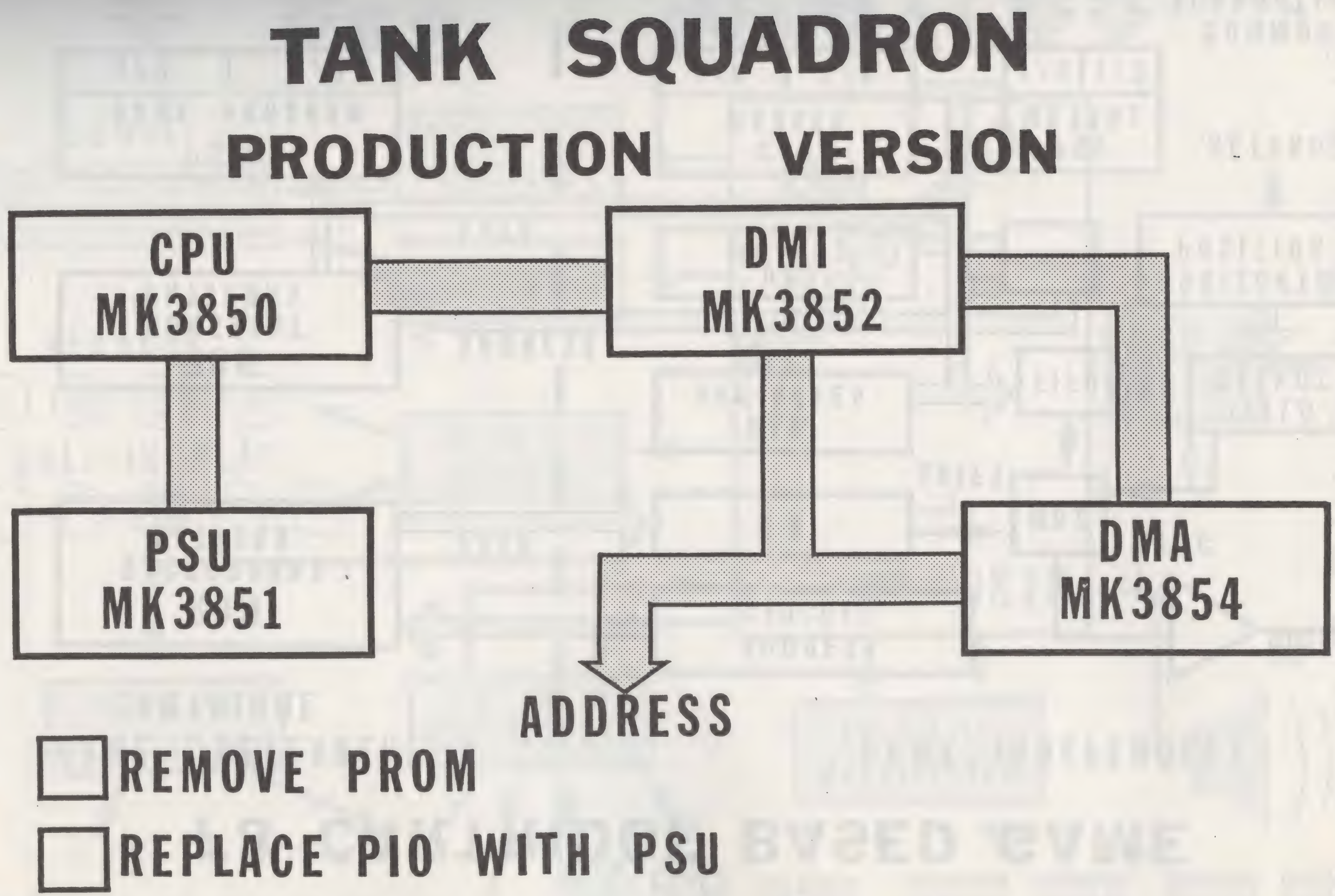
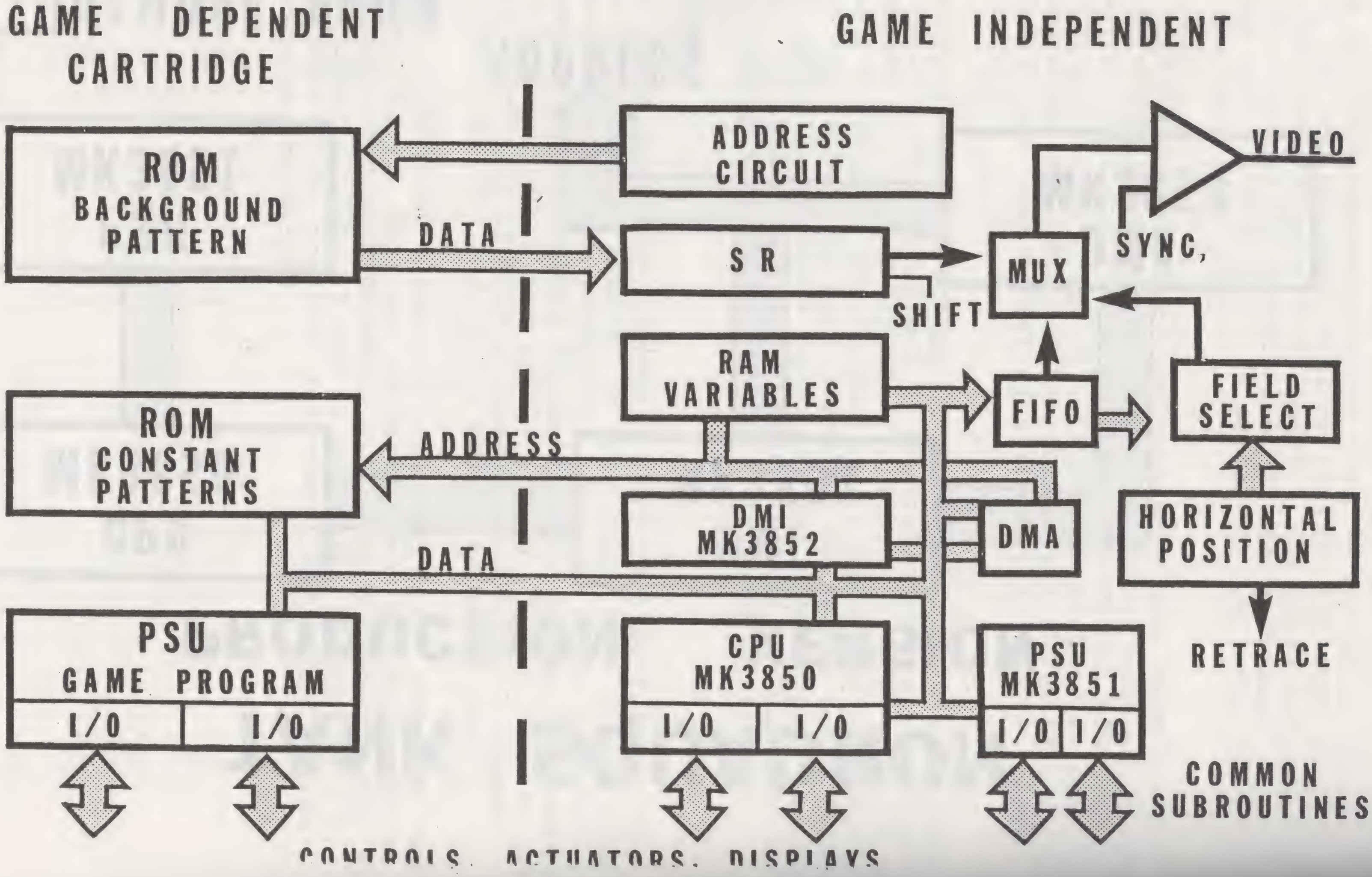


FIG. 13 - TANK SQUADRON PRODUCTION VERSION

F8 CARTRIDGE BASED GAME



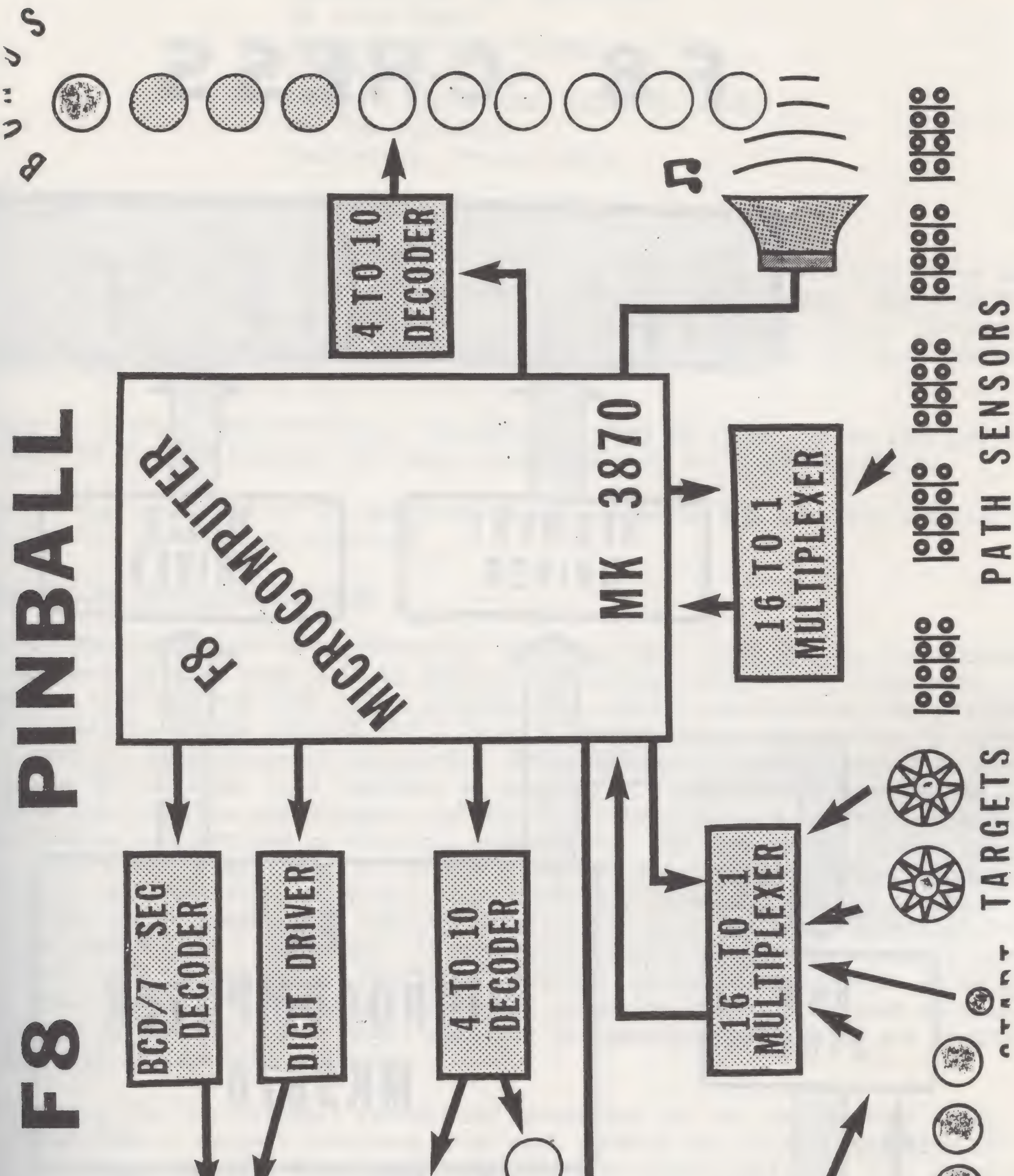


FIG. 15 - F8 BASED PINBALL GAME

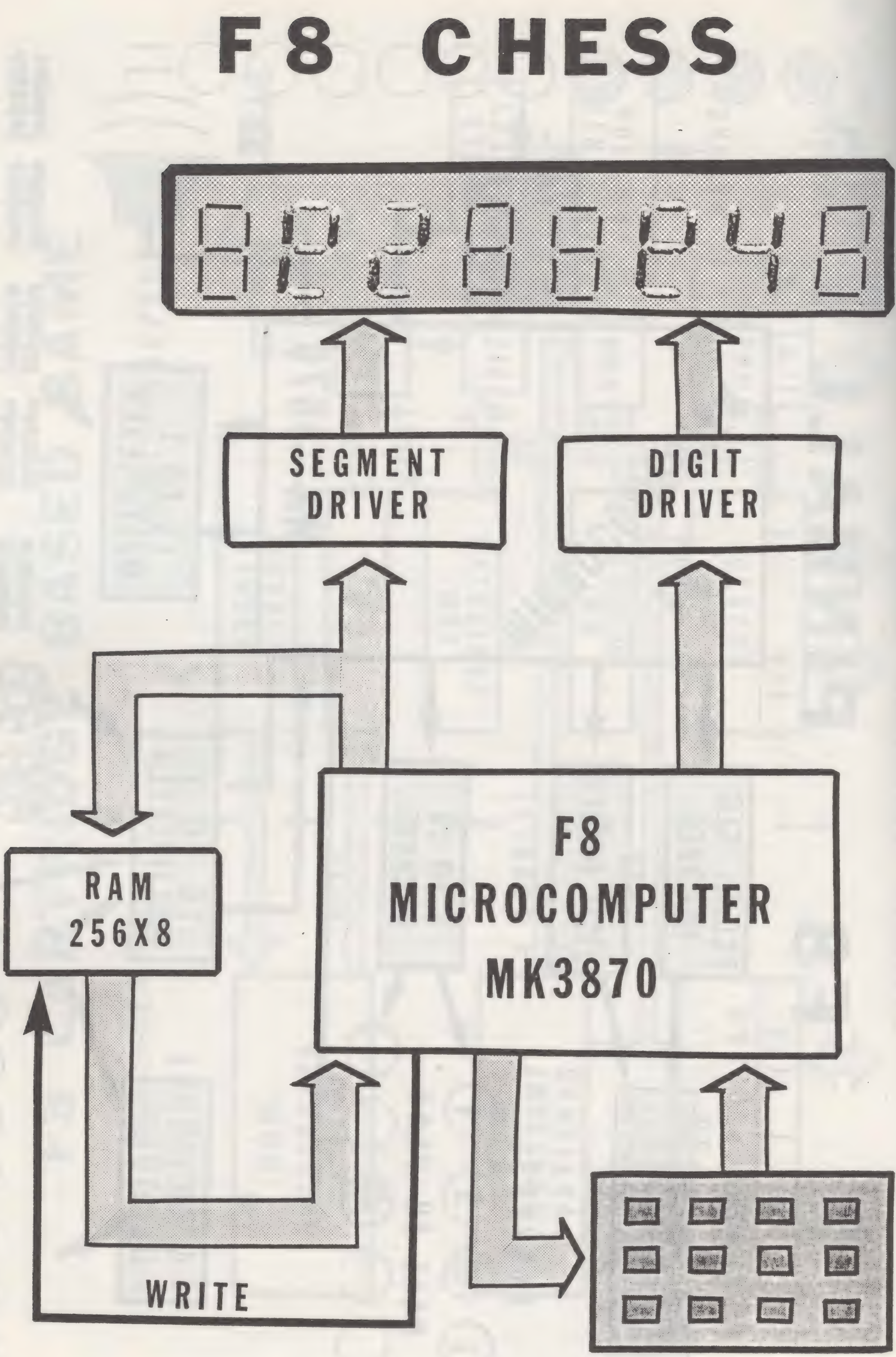


FIG. 16 - F8 CHESS COMPUTER

CAPABILITIES AND LIMITATIONS OF VIDEO GAME INTERCONNECTION SYSTEMS

ROBERT L. SHAY, JR.
Manager, Industrial Sales Division
AMP Incorporated
Harrisburg, Pennsylvania

Introduction

This program is being tenured in an effort to offer some innovative ideas and methods of interconnecting printed circuitry, chips and hard wiring. The objective is not just to afford economics for lower installed costs factors but to proceed from here with extensions of the basic precepts and apply them to the resolvement of specific applications.

Prior to product presentation, consideration must be given to one important factor that is a major decision for any interconnection and that is plating.

Can we and/or should we use un-noble or noble plating and what are the limiting factors for the application involved?

Gold Vs. Tin on Connector Contacts

An electroplater made the observation recently that after all the high-powered design engineering that goes into an electric connector, followed by precision stamping and forming, and high speed assembly and application tooling, the ultimate success or failure of the product still depends on those last few microns of material which he puts on the surface of the parts. And someone else characterized an electric connector as two platings held together by supporting structures of base metals. While these descriptions are somewhat facetious, it is difficult to over-estimate the important of the surface of electric connectors. The surface materials, its hardness, ductility, elasticity, - its electrical conductivity, oxidation rate, work function and catalytic activity, - its adhesion, cohesion, melting point, boiling point, vapor pressure, - and its porosity, density, galvanic potential and temperature coefficient - these are all important considerations for electric contacts in principle, theory, and actual practice. Without belaboring the point, it is simply observed that each of the properties mentioned above has been the subject of detailed investigation at one time or another, relative to specific problems in the application and performance of electric contacts.

The reason for the interest in surface properties is, of course, that these surfaces must form a contact interface that will provide for uninhibited flow of electric current across the junction. In modern electronic equipment this simple-sounding function cannot be regarded casually as a trivial matter. In more and more cases we are finding that the overall reliability of electronic systems is governed by the reliability of its interconnections rather than its active solid state components.

High reliability often bears a high price tag. With electric connectors, the price is significantly affected by the choice of whether or not to use gold on the contact surfaces, and how much must be used. The skyrocketing price of gold has caused many people to take a hard look at the necessity of using this very costly metal on connector hardware.

Re-evaluation of the requirement to use gold is a good thing, and undoubtedly many cases of usage will be found where it is a luxury rather than a necessity. On the other hand, the decision to use low-cost alternatives to gold plating should be based on rational engineering criteria as well as cost factors.

Reasons for Using Gold

Gold plating is used on connector contacts when it is required to handle low-level signal voltages and current with high reliability. The over-simplified statement of justificarion of gold plating needs to be examined in some detail in order to come to grips with the question of whether or not it can be eliminated.

Gold is a noble metal. By this, it is meant that gold does not easily react with other substances, and in particular, it does not react with the atmosphere to form oxide or tarnish films on its surface. In this respect it is unique among metals. No other metal, even the precious metals like platinum and rhodium, are as completely free of oxide films. In electric contacts this is a very important attribute, because oxide films are contact insulators. When surface films are present they must be removed, mechanically, electrically, chemically, or thermally before adequate electric contact can be established between conductors.

With all its advantages, gold is not needed or desirable for all contact applications. It is of no value in arcing contacts, for instance, where it erodes rapidly and has a strong tendency to weld. And the sliding wear characteristics of pure gold are not very favorable. It tends to stick, gall, smear, and wear-off fast. Its use on high pressure semi-permanent connections or in crimp connections is of dubious value other than in certain corrosive environments. The very characteristic which makes it ideal for some contact applications will compromise its use for other

Zero-Insertion-Force (ZIF) connector designs have also been proposed. ZIF connectors incorporate some mechanism whereby heavy normal forces are exerted on the contacts after engagement. Mechanical advantage can be built into the loading mechanism to reduce the human effort requirement in such a connector, and the severe wear problems associated with sliding under high normal force can be avoided. ZIF connectors have, in principle, enormous potential advantages. The expense of the added complexity of such a connector must, however, be weighed against the savings obtainable from the use of non-noble contact plating.

	Gold is Necessary	Undefined Zone		Tin is OK	No Plating
Contact Force	0 — 30 gms	30 gms	100 gms	100 gms up	1 Kg
Insertion Force/ Contact	0 — 100 gms	100 gms	200 gms	200 gms up	2 Kg
Engagement Wipe	when none available	small or none		with slide	with slide
Wear Cycles	1,000	100	10	10	10
Circuit Voltage	0 — 1.0 volts	1 volt — 30 volts		30 volts	100 volts
Current	1 amp	1 amp	10 amps	10 amps	0.1 amps & up*

*Provided other criteria for No Plating are met.

The alternate to gold plating in this area is tin (or tin alloys) - in terms of frequency and quantity of present-day usage, as well as in terms of cost and efficacy. Tin is not a noble metal. It and its alloys do form oxide films in normal air exposure. In moderately severe environments the tin surface can become heavily coated with oxides or other non-conductive corrosion products. Its usefulness as a contact material lies in the fact that tin is a very soft material and its oxides are comparatively hard and brittle. It is consequently relatively easy to break through the oxide film mechanically so as to establish metal-to-metal contact with the underlying tin base. But certain minimum values of mechanical force, motion, and geometry are required to accomplish this breakthrough of films, and some of the selection criteria are related to the availability of those minimum mechanical requirements.

I. Tin Plated Contacts Need at Least 100 grams Normal Contact Force

Higher forces are desirable whenever it is possible to provide them. Limitations on the high force side are usually determined by:

a. Total effort required to engage/disengage multiple-circuit connectors, due to high friction.

b. Wear on the plating, from large numbers of durability cycles. Durability cycling requirements of 50 cycles or more is considered large.

c. Physical size and strength of contact spring members.

d. Spring deflection requirements. Dimensional tolerances sometimes require resilient springs with large deflections so as to accommodate max and min. tolerance conditions between mating contacts. This may be incompatible with high contact force in the worst-case condition.

II. Contacts Must be Mechanically Stable in the Mated Condition

Motion of the contact interface during its service life is the single most important cause of failure of tin plated contacts. Relative motions of about 0.1 mil or greater are sufficient to break the gas tight seal at a tin-tin interface and allow formation of oxide film. Small cyclic motions of this kind, as might be caused by vibration or mechanical disturbance, or by thermal expansion/contraction, are called "fretting motions". Fretting motion results in fretting corrosion, which is simply an accelerated oxide film growth at the contact interface caused by the constant exposure and re-exposure of clean metal due to the relative motion.

Fretting Motions

Three types of fretting motion are illustrated. Rocking and Rotation are worse than Translation in some respects, since there is no self-cleaning action associated with these motions.

The severity and seriousness of fretting motion may be demonstrated on an apparatus which produces a $\pm 5^{\circ}$ rotational motion. Clean tin plated contacts having an initial resistance of about 1 milliohm will develop over 1 ohm resistance in less than 30 minutes on this apparatus, which frets at 10 cycles per minute. (lubricated tin plated contacts and gold plated contacts show no change in the same test).

Mechanical stability as used in this guideline refers to the prevention of any of the three types of fretting motion.

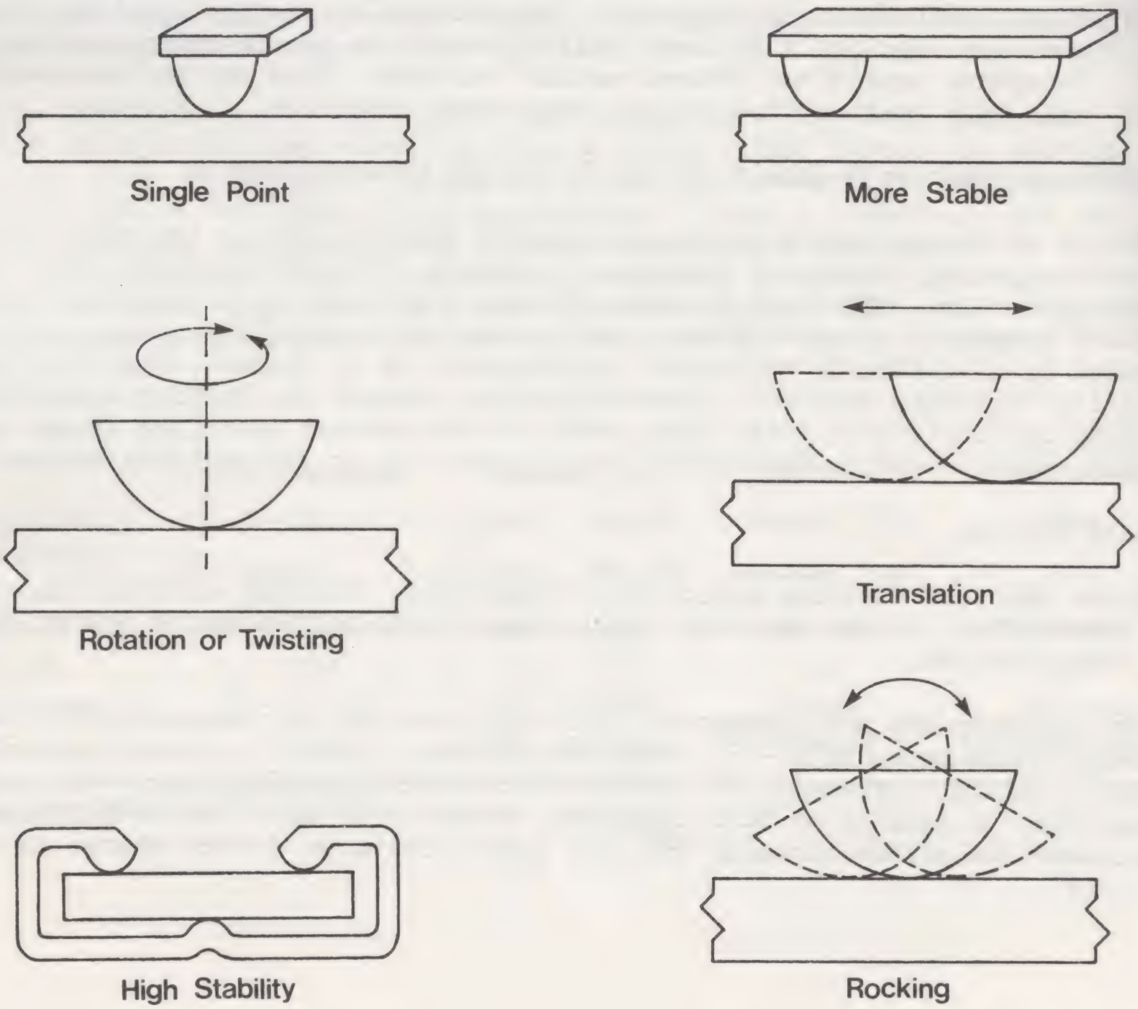
a. High contact forces tend to produce highest stability.

b. Large interface areas tend to be more stable--particularly against rocking and rotational motions.

c. An interface consisting of two or more discrete contact points, spaced apart from each other, tend to be more stable against disturbance motions.

d. Motions due to differential thermal expansions of the contact housing/mounting hardware are insidious and dangerous, and are often overlooked in design. Thermal cycling of the mated connector will show up this problem. It is controlled by choice of materials and/or by designing the contact configuration such that the expansion/contraction is accommodated somewhere other than the movement of the contact interface. As for instance, by elastic deflections of the contact members or their mountings.

Fretting Motions



III. Tin Plated Contacts Need Lubrication.

When it is not possible to achieve absolute mechanical stability--that is, freedom from any motion of the contact interface, protective lubrication is necessary. A thin liquid lubricant film protects contact surfaces from the detrimental effects of disturbance or fretting motions. It does so by:

1. Reducing friction and generation of wear particles due to motion;
2. Protects the surface from atmospheric oxidation, in and around the contact interface; and
3. Prevents fretting corrosion.

As contact forces approach the minimum recommended level of 100 grams, it becomes more important that lubrication be used from the standpoint of protection against fretting and disturbance motions. On the other hand, with higher contact forces lubrication may be necessary to reduce friction and wear during engage/disengage cycling of the connector. In this respect, lubrication will permit higher contact forces than would otherwise be allowed from friction force considerations.

IV. Sliding or Wiping Action During Contact Engagement is Necessary with Tin Plated Contacts.

Even the zero-entry force type connector should incorporate some wipe. The alternate is to provide sharp points on the contact to break through the tin oxide surface film. This is a less-satisfactory way of breaking through the films from the standpoint of wear life and penetration of the plating to the underlying base metal.

V. Tin Plated Contacts Must Not Be Used to Make or Break Current

Arcing will quickly destroy the tin plating.

VI. Tin Plated Contacts Can Be Used Under Dry Circuit or Low Level Conditions

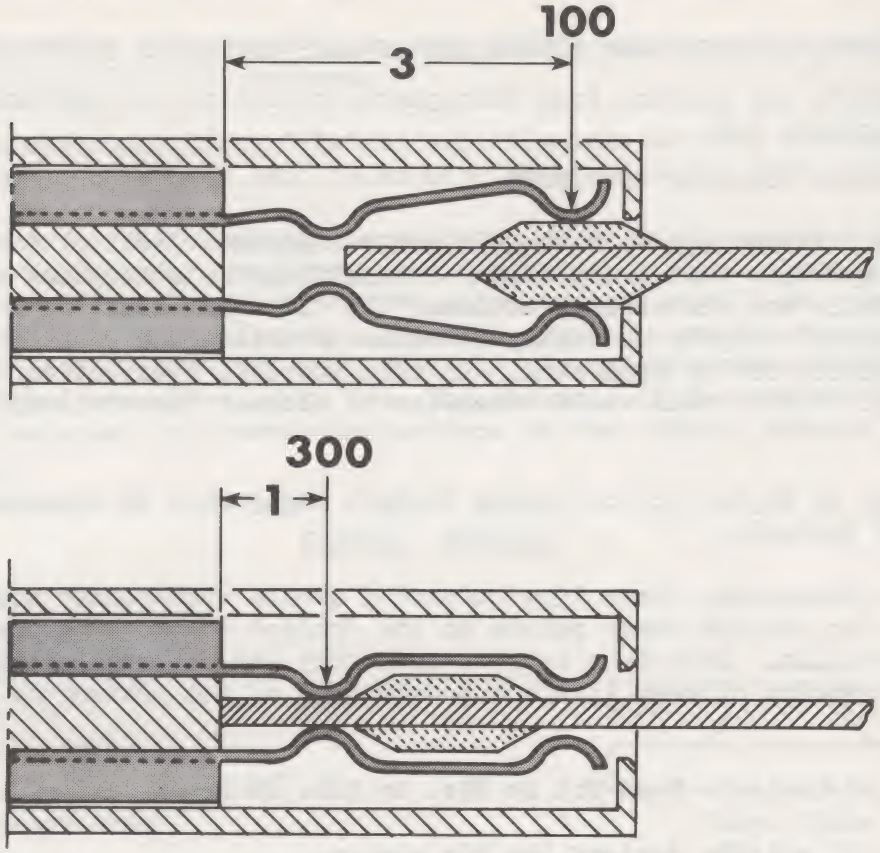
Under the guidelines set forth above, there are no limits to the voltage and current at which the contacts may be used. This includes microvolt/microampere levels as well as the volts/ampere region.

LOW FORCE CONNECTOR

The name "Low Force" relates to the entry force required to insert a printed circuit board. With a mechanical advantage to help lift the contact over the printed circuit board, some insertion force is required; but part of this force is recovered when the board snaps into place as the contact slips down the other side of the cam. At this time, the back lobe of the contact wipes down on the board with the required normal force. It allows a minimum amount of wiping action to preserve the plating on both board and contact.

This is a "plus" for durability. With tin plated contact and tin-plated covered pads on printed circuit board, samples proved good after 500 cycles of mating and unmating, even with a high normal force of 200 grams. Similar contacts with 150 grams normal force were cycled 1,000 times, and with lubricated contacts, samples were functional after in excess of 1500 cycles.

Printed circuit board preparation is an extra operation, but if components on the board need some protective cover, then the "cam bar" can be an integral part of this cover which is automatically installed with the cover.



Introduction

Pluggability of integrated circuits will continue as one of the paramount packaging requirements in system design. Increased emphasis on higher switching speeds will stimulate the application of ECL, CMOS, NMOS and PMOS devices.

The use of high normal forces, drives the insertion forces for multi-pin devices to totally unacceptable levels. The only acceptable method for eliminating insertion forces is a design that will cam and lock the contacts closed, thus, generating the high mated normal forces required for positive performance.

This is a design aimed at solving all the foregoing problems efficiently. Simply expressed, this means interconnecting with high mated normal forces from the logic package to the printed circuit board. Leaded packages plug into the ZIF connectors and are positively contacted and retained with dual

wiping, high normal force contacts. Interconnection to the Board is accomplished with either one or two options.

The ZIF Connector is directly mounted to the board and retained by riveting. Interconnection to the solder plated pads of the board is through a dimpled, limited wipe, high force, bottom contact.

The ZIF connector is directly mounted to the mother board and retained by the solder-tab legs which are soldered to the mating holes in the printed circuit.

Description

The multi-pin ZIF connector features a rigid housing either surface mounted or through-hole mounted to the board. The one piece contacts are automatically stitch loaded through the top of the housing. Each contact is securely locked into position through the action of the locking lance.

A thermoplastic SER rated material such as Poly-Phenylene-Sulfide, is the basic material for housing and cam members.

Contacts

One piece stamped, formed and dimpled contact interface of beryllium copper.

Heat treated beryllium copper is creep resistance, high in conductivity and stable over wide temperature range.

Features

DIP Leads Wiped and Mated Both Front and Back

Contact designed to mate simultaneously with front and rear sides of DIP legs as cam is activated thus, providing redundant contact interface.

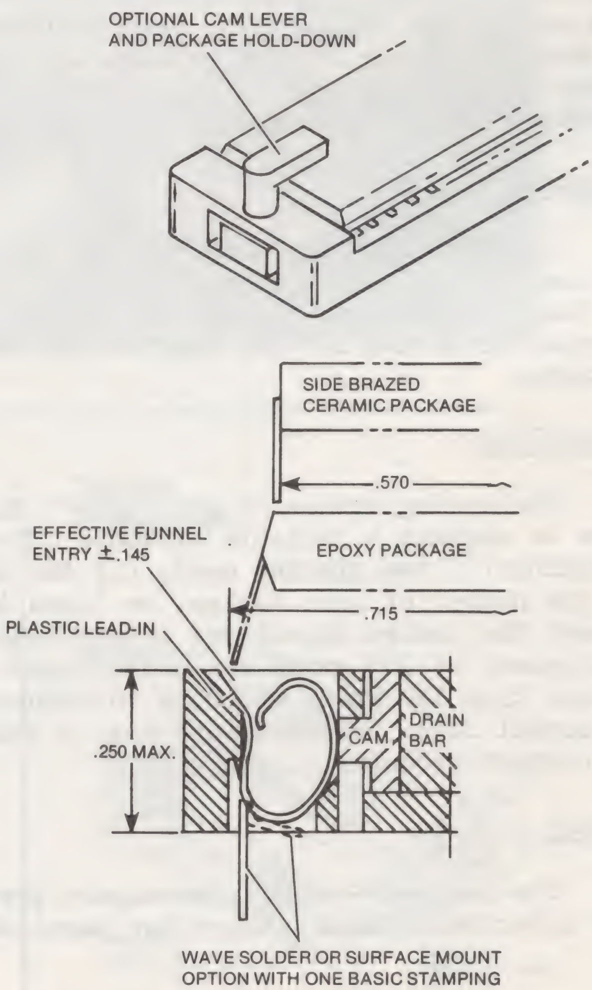
Open Face Housing Design Eliminates Stubbing of DIP Leads.

Generous lead in eliminates stubbing of DIP leads during insertion.

Contact Repairability

Contacts are easily replaced.

LOW PROFILE ZIF RECEPTACLE
40 POSITION — 1.51



This section describes a contact and connector fabrication technique for board-to-bard interconnections that combine high-production metal stamping and forming with thermal plastic-to-metal bonding. The number of interconnection elements is significantly reduced as are the assembly operations required. The result is a highly reliable, versatile connector of minimal size, weight, cost and complexity.

The Contacts

Tin-plated contacts are stamped from a strip of 0.010" phosphor bronze. The strips are then formed into shape. Since the contact engages both sides of the board, connector terminal pads can be located on either or both sides of the board. This offers the packaging engineer the versatility of using any combination of the four inside and outside board edges.

Adding to the versatility of this contact is the residual spring force designed into both the clip portion into which the board is inserted, and the bend at the center of the contact. This assures a reliable connection between warped or bowed printed circuit boards.

The Connector

Production of a board-to-board connector is greatly simplified by laminating the blank strips of contacts between two layers of thermal plastic. Labor and material costs normally associated with the loading of individual contacts into plastic connector bodies is wholly eliminated. In addition, circuit complexity is greatly reduced. This unique fabrication technique also eliminates the high cost of tooling required for each different size of molded connector housing. One set of tooling is used to form what amounts to a very long connector of common contact and board spacing. Any number of contacts can then be cut off offering the packaging engineer a very large variety of connector sizes.

Connector Housings

In those applications where the connector must undergo repeated extractions and insertions, a more rugged version of the connector may be more appropriate. For these situations, a simplified body has been designed that can be inexpensively extruded or molded in long lengths and then cut to fit any required number of contacts.

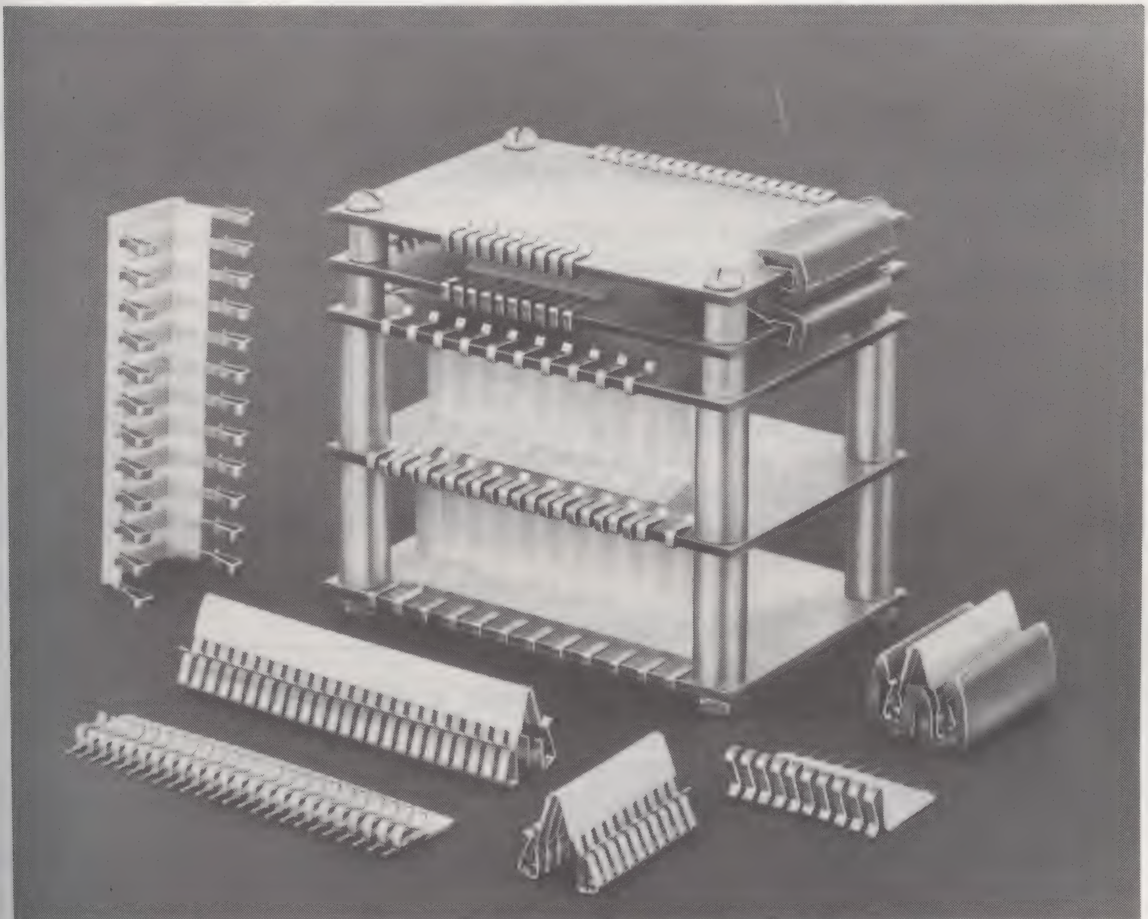
Reliability

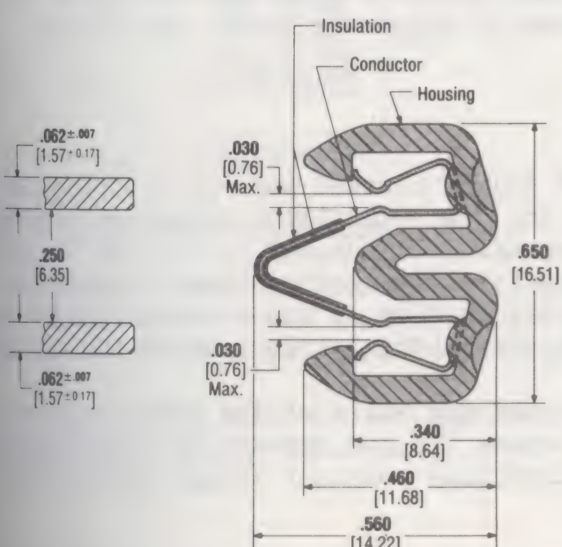
The spring system of any contact must, of course, provide sufficient normal force to sustain a reliable circuit. The normal force depends on many factors including (1) the plating used, (2) the acceptable insertion/extraction forces, and (3) the number of wear cycles, or times the connector will be inserted and extracted. To meet the design objectives of a reliable connector, a nominal normal force requirement of 200 grams was established. Under the worst conditions, a force of no less than 100 grams would be tolerable. Once the general shape of the contact and normal force criteria were set, a computer study was implemented to optimize the contact geometry.

Summary

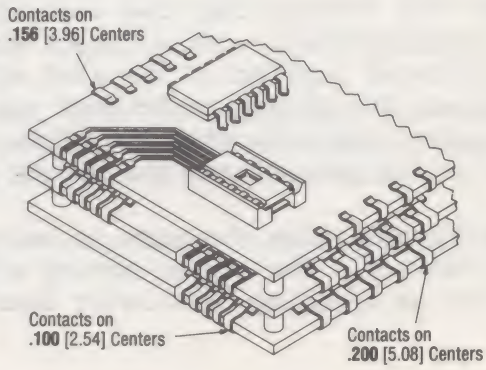
The board-to-board interconnect system is designed to provide reliable, low cost interconnections between two parallel mounted printed circuit boards. By

combining high production metal stamping and forming techniques with thermal plastic to metal bonding, the number of connector elements can be significantly reduced as can the number of assembly operations. In addition, the versatility of the fabrication technique minimizes the tooling necessary to supply any number of contacts on any contact center spacing and for virtually any board spacing. By adding an inexpensive connector body, or by changing the configuration of the contacts, this concept can be applied to a wide range of printed circuit board interconnection problems.





Typical Application



Insulation Displation Connector

The Lace-N-Lok cable-to-post connector uses an insulation displacement technique for simultaneously terminating a group of discrete or ribbon wires, thereby minimizing total labor in attaching wires to a connector assembly. The wires require no preparation since the tooling trims them to proper length and the terminal displaces the insulation to make an extremely reliable electrical connection. Since the connector is furnished with the contacts fully loaded in the housing, Lace-N-Lok product offers additional labor savings by not having to load individual contacts into the housing after wire termination.

The insulation displacement means of wire termination, after successful use in the telephone industry, is now meeting increasing industrial acceptance. Although the termination has a rather fragile appearance it is actually a rugged, dependable terminating technique.

Connector Description

The Lace-N-Lok cable-to-post connector family is available in 2 through 18 positions. All contacts are preloaded in the housings, simplifying ordering, inventory and assembly. It is designed to mate with an assortment of tin-plated posts; either .045" square, .045" round, or .031" x .062".

The contacts for the connector are made from tin-plated brass while the housing is constructed of a flame retardant thermoplastic material rated by Underwriters Laboratory as 94V-0.

The Lace-N-Lok connector meets 3 basic requirements:

1. A high force contact system incorporating a good wiping action on the mating post.

2. Use of a contact lubricant.

3. Provision for contact stability to reduce relative motion between the two mating parts of the connector system.

Contact stability is achieved by plastic fingers molded into the housing at each contact position. These spring fingers hold the post firmly after it is inserted into the connector. Redundant tin-plated contacts captivate the posts at the opposite end of the connector. This system of support at both ends of the post provides a firm and stable condition.

Basic Termination Concept

The wire terminating area consists of a double slotted beam in a "U" shaped terminal configuration with a funnel area at the top. Insulated wires are positioned in the uppermost portion of the slot either manually or automatically. As the tool is activated, the wires are trimmed and forced into the slotted beams, displacing the insulation and deforming the wire. This deformation of the conductor breaks down any oxides present and the wiping action cleans the inside area of the slots.

At the same time the wire is being deformed the walls of the slot are forced slightly outward. The stored spring energy causes the two side walls of the slot to function as opposing cantilever beams, maintaining constant inward pressure to

maintaining constant inward pressure to insure a gas-tight metal-to-metal contact. The terminal provides four independent points of contact to the terminated wire.

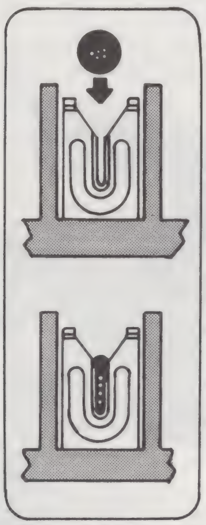
Insulation Support

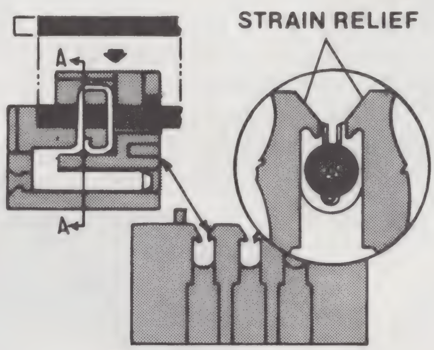
Strain relief for the wire is built into the plastic connector housing. As the wires are terminated plastic spring fingers collapse and allow the wires to pass through and become captivated. Lateral motion to the wire, therefore, is not transmitted to the points of termination because of the restraint provided by the plastic housing.

Termination Reliability

Both short and long term reliability of the termination technique is outstanding. The slotted beam concept is used in the telecommunications industry where such connections are required to maintain a stable resistance for a projected life of 40 years. The Lace-N-Lok connector is designed to accept #24 and #22 AWG solid and fused stranded or #22 stranded wire. These wires will withstand a tensile of over 10 pounds for #24 AWG and 15 pounds for #22 AWG in the axial direction, and approximately 8 pounds in the direction perpendicular to the normal wire position. The constant pressure exerted on the wire by the walls of the slot gives the technique the ability to maintain relatively constant forces over a very long period of time and a wide range of temperatures. Any wire creep that may take place is compensated for by the resiliency of the current structure. For applications requiring different wire sizes the slot dimension can be varied to accommodate them.

Connectors have Keying capabilities.


SECTION "A-A"



Lace-N-Lok Application Tooling

Available tooling varies from a manual hand tool for individual wire insertion, manual or pneumatic bench presses or fully automatic assembly equipment feeding discrete or ribbon cable, mass terminating one or both ends of the cable.

Single ended terminations may have discrete conductors with different and varying lengths at the other end.

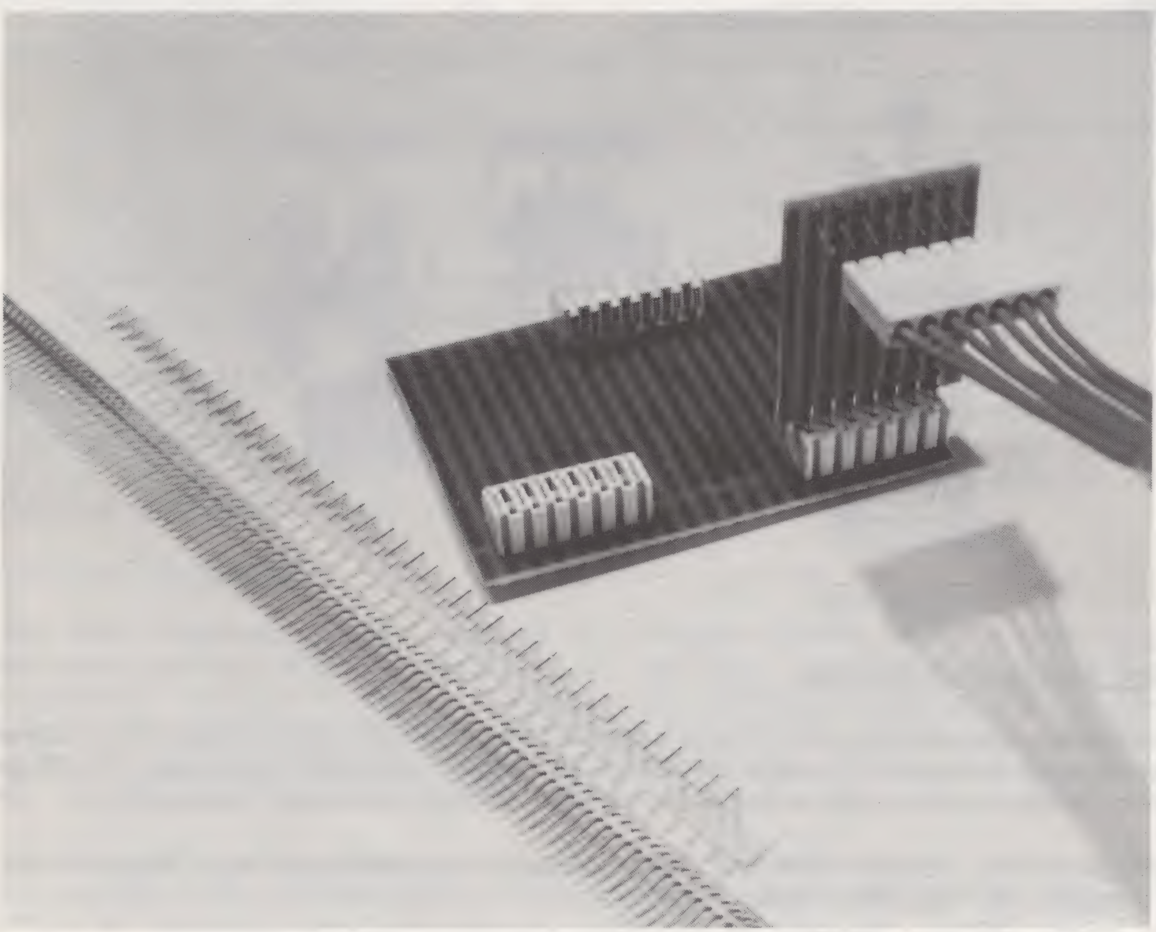
Commercial Interconnection System

Herein referred to as CIS, the system consists of a wide range of connector housings with specially designed cavities to support and protect relatively high pressure fork type contacts. The housings are mounted ready for wave soldering to printed circuit boards without tooling. The mating half is an $.025^2$ post in 90° or 180° configuration having a long contact travel area that insures positive wiping action for electrical continuity and excellent mating characteristics.

Design of the fork type connector housings provide for wide tolerance of misalignment to assure correct mating with the post contacts. Post contacts are available in continuous strip form for high speed automatic machine insertion or on a plastic carrier strip for multiple staking to printed circuit boards.

Pre-assembled housings are provided with contacts on a .100 or .150 centerline contact spacing. Contacts are brass with bright tin over copper plating for excellent solderability. This versatile interconnection system for wire to board or board to board application provides for side, top and bottom entry of the $.025^2$ post into the receptacle housings. This enables the systems design engineer to be flexible in planning his interconnection requirements.

Fully automated application tooling has the capacity to measure, cut, strip and terminate conductors up to the rate of 5400 leads per hour, terminated at one or both ends for high production excellence.



GAME POWER SUPPLY CONSIDERATIONS

JAMES F. MCNULTY
Vice President/Product Manager
Adtech Power, Inc.
Anaheim, California

Coin operated video games in many cases approach minicomputer complexity with up to several hundred IC chips involved in a rather hostile environment. These games sell at prices from \$500 to over \$2,000 and are expected to take in between \$200 and \$1000 per month. The prime considerations for game sales are: game interest, reliability, appearance, and cost. Reliability is a major factor for the following reasons:

1.) The distributor and operator groups are a fairly tightknit organization (Music Operators of America) and have many trade publications such as "Playmeter", "Coin Amusement", etc. Any field failure problems with a game become widespread knowledge in short order and greatly hinders sales of subsequent games by the offending manufacturer.

2.) Field service personnel from most distributor or operator organizations are usually electromechanically oriented and usually do not have the test equipment or skill for detailed circuit analysis and repair. Therefore, maintenance is usually on a modular level, i.e. video display, games board, or power supply. This frequently means long down time waiting for replacements and high warranty, freight, and repair cost to the manufacturer.

3.) The loss of operator revenue due to down time affects the manufacturer in two ways. There is an immediate loss of profitability due to abnormal warranty, freight, and repair cost and lost sales time in satisfying the irate customers and a second long term loss of revenue in future games sales due to the prior problems.

GAMES FAILURE MODES

Assuming a sound game design, most game failures fall into one of the following eight categories. Although most of these problems are not power supply induced, many can be eliminated by good power supply design.

1.) Infant mortality component failure.
2.) Heat induced failures.
3.) Erratic operation due to line noise.

4.) Erratic operation at low line conditions.
5.) Catastrophic failure at high line operation.
6.) Game board or audio board signals causing spurious video signals on display.
7.) Static discharge failures (or free game operation).
8.) Power supply failure due to overload.
9.) Shock and vibration failures.

SOLVING THE PROBLEMS

1.) Infant Mortality Component Failures

Most game manufacturers have found that a 48-hour burn in of the completed system will practically eliminate these failures, while buying from reputable manufacturers (including the power supply) will greatly reduce the number of failures(and the high rework costs) during burn in.

2.) Heat Induced Failures

While most computers use metal cases for good heat transfer and adequate venting for good convection cooling, most coin operated video games operate in a totally enclosed wood or fiberboard cabinet with no venting. This is done to prevent spillage into the games or probing with wires, etc. to attempt to get free games. As a result, the heat environment of the game is considerably worse than that of most computers with heat rises of 20 to 40°C. not uncommon. Heat induced failures generally occur as a function of both time and temperature and will usually occur after weeks or even months of operation. This is the major cause of power supply failure in the games.

Most O.E.M. power supplies use a minimum amount of heat sinking depending on the excellent thermal conduction and good convection cooling of most electronic equipment for their cooling. A 5 volt 6 amp supply that will operate at full power for years in a well cooled computer, will frequently fail at 5 amps operation after a few weeks in a video game. The failure most frequently is rectifier failure in the many O.E.M. supplies that use parallel 3 amp diodes for rectification, and pass transistor or filter capacitor in the better designed units. To overcome this problem, Adtech Power uses 50% more heat sink, a pass transistor with twice the power rating, rectifiers with up to 5 times higher rating, and a larger 10-year life filter capacitor. Another solution is to use a power supply with at least 50% higher rating than that required, i.e. a 5 volt 9 amp power supply for the 6 amp application.

Fortunately, most coin operated game cabinets have a surplus of room and some judicious layouts can prevent many heat problems. The game board should be mounted vertically close to one side of the cabinet and as low as possible to allow the heat rise away from the board. As much copper as possible should be left on the board to act as a heat spreader. The power supply

should be
mounted on the bottom at the side opposite the game board, <u>never</u> under the game board.

The inside of the cabinet can be rough sprayed with flat black paint to improve heat absorption and help transfer the heat to the outside world.

Whenever possible, some judicious bottom vents located under the games board and the chassis edges of the power supply with some well screened upper vents under the table top (or rear of upright cabinets) should be used to provide some convection cooling. This alone would solve many of the existing heat failure problems.

3.) Erratic Operation Due To Line Noise

Most coin operated games operate in an environment with electromechanical pinball games and other games with solenoids, relays, and motors that generate fairly high spikes on the power lines. These high frequency spikes are generally passed through the usual power supply with very little attenuation since they are above the regulators frequency response. These signals can cause false responses from the game circuits and are extremely difficult to isolate since they may occur randomly.

This problem can be solved by using high noise immunity circuitry and filtering all lines, or by installing an expensive AC line filter. A much simpler and far less costly solution, however, is to use an electrostatically shielded transformer with a high frequency bypass on the secondary in the power supply. All Adtech Power supplies use this system and it has completely solved the noise problems of several game manufacturers.

4.) Erratic Operation At Low Line Condition

As more sites cram more games into a given floor space, the power lines are loaded more severely and the line voltage drops. I have seen 3 and 4 games operated from an undersized extension cord. Also during peak periods, power companies may reduce the line voltage 5% to reduce generator loading. This means that many games are nearly permanently operating under low line condition.

While most O.E.M. supplies are rated to operate from 105 to 125 volts, under extensive operation in the higher heat environment of the video game, they may drop out of regulation causing excess ripple and erratic operation as high as 110 volts. A common symptom of this problem is a premature end of game signal. Adtech Power uses a 20% larger transformer to provide an extra 5% reserve to prevent this problem and permit operation as low as 100 volts when hot.

Using a higher rated supply as previously mentioned is another way to solve this problem.

5.) CATASTROPHIC FAILURE AT HIGH LINE OPERATION

This is nearly always a power supply problem caused by a marginal power supply design coupled with a high temperature environment. The use of a higher powered supply will not necessarily solve this problem since operating a power supply well below its ratings actually increases the voltage stress on the rectifiers, filter, pass transistor, and IC. The solution is to use a well designed power supply from a reputable manufacturer.

6.) Game Board Or Audio Signals Causing Spurious Video Signals

This usually occurs when the game board and/or audio board is operated from the rather crudely regulated 5 volt auxilliary supply on the video monitor and is caused by the lack of isolation between the auxilliary supply and the video power supplies. Signals from the game or audio board can couple directly into the video circuitry and even cause oscillations.

The best solution to this problem is to use a separately isolated power supply with electrostatically shielded transformer which will completely eliminate the problem. Other solutions are parasitic suppression and high frequency filtering of the auxilliary supply lines at some further degradation of regulation.

A similar problem of undesired interaction can occur when the games board and/or audio board use two or more different voltages from a common supply, such as in microprocessor applications. To avoid this problem, Adtech Power uses separate isolated secondary transformer windings and separate high frequency bypasses to prevent interaction. Additional filter circuits would eliminate this problem also.

7.) Static Discharge Failures

One of the major problems encountered especially in the new carpeted arcades is static discharge from players. Static discharge to the coin box will usually result in a free game. In fact, several juveniles have been caught using spark coils purposely to get free games from these machines. Frequently however, the static discharge will cause failure of the game. While a good power supply will not prevent these failures, the electrostatic shield of the transformer provides an excellent low impedance ground point for eliminating static discharge.

All external metal points including controls, switches, coin box, escutcheons, CRT shield, etc. should be tied as directly as possible with 20ga. or heavier wire to the electrostatic shield and 3rd wire ground. Note: Even controls with plastic knobs must be grounded since the high voltage (up to 40,000 volts on a woman with nylon clothing) discharge is sufficiently high to arc through the plastic knob to the metal shaft (ever touch a plastic light switch on a dry day?). Of course, a 3 wire line cord and outlet are necessary for this grounding to be effective.

8.) Power Supply Failure Due To Overload

This failure is quite common on video monitor supplies which have no current limiting and on "in house" low cost power supplies that have basic current limiting or no current limiting. The problem is frequently caused during test or servicing by accidently shorting the supply lines. It may also occur due to a chip failure or other load short. The result is catastrophic. The series pass transistor fails shorted due to excess current if no limiting is used or due to excess dissipation when the entire voltage at 110 to 130% of rated current appears across it. The high current clears the external short (or the tester removes the short) and the full unregulated upstream voltage then appears on the output busses destroying at least several chips on the game board. This not only increases the cost of reapir bu t the multiple fault makes diagnosis and repair more difficult and may greatly increase down time if only one replacement module is ordered and could result in a second failure.

This problem is practically unheard of in good quality O.E.M. power supplies since they all employ foldback current limiting, as the current attempts to increase beyond about 120-130% of load, the output voltage falls. As the output voltage falls, the foldback circuit reduces the output current until at short circuit, the output current is less than half the rated current. As a result, the dissipation on the series pass transistor during short circuit is actually less than the dissipation at normal full load and the power supply is undamaged. The solution to overload failures is to employ foldback current limiting with a foldback ratio of at least 2:1 on 5 volt supplies and 3:1 or more on higher voltage supplies.

We have pretty well covered the field reliability problems that can be encountered other than the video display and coin box problems and broken controls. Now I would like to cover the design considerations for games power supplies.

DESIGN CONSIDERATIONS

The prime problem for any power supply is heat. Due to the increase of chemical activity with heat, capacitor life will increase 50% for every 10%/^{o}C. rise above rated temperature; similar life shortening occurs in the transformer insulation. Power transistors also have a life limiting function due to thermal cycling which causes fatigue failure of internal connections due to the different thermal coefficient of silicon and the metallic elements. A 25^{o}C. temperature rise can half the thermal cycle life.

The larger the heat sink or chassis area, the longer the life and higher the reliability of the supply in general. However, the cost increases proportionately so there are some practical limitations. UL allows a maximum average chassis temperature rise of 65^{o}C. above a 25^{o}C. ambient. This establishes a practical minimum size chassis or heat sink. A 65 C. rise corresponds to 0.6 Watts/

sq. in. of surface area. While this is barely adequate for a well cooled computer it would not be adequate for most video games applications. Adtech Power uses an area adequate to provide 0.32 Watts/sq. in. and a maximum rise of 40°C. at 120 volt input. This is adequate to provide at least a 15% margin on our transistor junction temperatures even at a 40°C. outside ambient and up to a 40°C. internal ambient temperature rise.

To design our theoretical power supply, we, of course, must know the required output voltage and current, the required line voltage range, and the maximum ambient temperature in the vicinity of the power supply. And of course, the regulation required.

For instance, T^2L chips will tolerate a voltage change of $\pm5\%$, however, load wiring drop will generally be about 1 - 2%, on long wire system it could be close to 5%. The temperature drift of the better power supplies will be .02%/°C. and on the cruder discrete supplies as much as 0.1%/°C. which will cause another 1.1% to 5% deviation for a 40°C. ambient and 40° rise. Another 1 - 2% should be allowed for metering errors. PC Card and connector drops will account for 0.1 -0.25% deviation. Ripple will cause a further deviation of 0.1-0.25%. So to maintain a $\pm5\%$ reg. at the IC, our power supply usually has to maintain better than 1% overall line plus load regulation which is no major problem.

Our first requirement is to determine the required unregulated DC voltage.. If an IC regulator is employed, the input voltage to the IC generally must be 3 volts above it's output voltage. Since on power supplies above 1 amp, a Darlington output stage will be required to keep the IC below safe dissipation area at high temperature, the IC output will have to be about 1.3 volts above the Darlington output voltage. Generally an additional 0.6 volts will be required for our current sensing resistor and 5% of the output voltage will be required to permit adjustment to compensate for output line drops, etc. In addition, the unregulated voltage has a considerable ripple content if we limit ourselves to economically practical filter capacitor size. This ripple will generally be 4 - 5% RMS or 5 - 7% peak. Since our regulator will drop out of regulation on the negative peaks of the ripple, our minimum voltage must be set above the required minimum DC input by that amount. Our power transformer will have an I^2R loss of 3 - 5% and since the resistivity rise of copper is 0.39%/°C., when the transformer is running at it's maximum temperature (about 100°C.), we must allow for this additional 29% of 5% drop or an additional 1.5%. Since all but the output voltage must be dissipated in the supply, it can be seen that for a 5 volt supply, the efficiency is extremely low especially when V in. min. is multiplied by 1.11 for nominal line. This would give us less than 34% efficiency when the rectifier losses and transformer losses are considered. To improve this situation, Adtech Power uses a boost supply to provide the input to the IC regulator only, permitting the main supply to go down to the saturation voltage of the power transistor. In this case, our dissipation is reduced by nearly 25%. The worst case dissipation at high line 110% load will be Pmax= $[(V\ in.\ nom. \times 1.1) - V\ out \times]$

1.1 IDC. The chassis surface area required:
$A=\frac{Pmax}{32}$ sq. in for a 40^{o}C. rise.

SERIES PASS TRANSISTORS

The power transistor required must be rated for a voltage of 2 x V in nominal and a current of at least 1.5 x the required current with adequate worst case DC current gain to require less than 25ma of drive current. The power requirements will be met if the transistor meets these requirements:

$Tj\text{-}c - \theta jc \times Pmax$

$Tj\text{-}c \leq Tjmax - \left[60 + Tamb\,max + (.5 \times Pmax)\right]$

$60 = 40^{o}C.$ chassis rise + $20^{o}C.$ safety margin
$(.5 \times Pmax) = Ths\text{-}c$

If this requirement is not met, a higher powered transistor with lower $\theta j\text{-}c$ or parallel transistors must be employed.

The transistor parameters must also be checked to assure that all combinations of voltage and current through the overload and short circuit points fall within the safe operating area of the transistor.

In high temperature environments it is generally undesirable to use plastic power transistors at high power levels. If the transistor is mounted to the chassis and the pins are into a PC Board, this places mechanical stress on the lead junction and thermal cycling may eventually fracture the seal causing failure. On low power levels where there are no mechanical stresses on the transistor there is no objection to plastic devices.

RECTIFIER FAILURE

One of the most neglected areas of power supply design is the rectifier filter requirements. Even many O.E.M. manufacturers will attempt to use parallel 3 amp rectifiers in a 6 amp supply. During the initial turn on of a power supply, the discharged filter capacitor appears as a short circuit and the peak rectifier current is limited only by the source impedance of the transformer. This first half cycle surge will usually be about 10 x the rated DC current and on heavy supplies, can approach 20 x the DC rating. The surge current rating of a rectifier decreases with temperature in accordance with its power derating curve. 3 amp diodes with surge current ratings as high as 200 amps at 25^{o}C. (derated to 50 amps at 125^{o}C. where the rectifier is usually working) are available; however, the lower cost 3 amp diodes have surge ratings as low as 50 amps at 25^{o}C. The most common failure on these supplies is rectifier failure when the supply is repeatedly switched on and off while hot. For this reason, Adtech uses large 30 amp dual rectifiers with a surge rating of 250 amps at 100^{o}C. even on their 6 amp

supplies. To avoid this problem be sure your rectifiers are rated for a ½ cycle surge of 20 x the DC current at the expected diode max. junction temperature. The P.I.V. of the rectifiers must be at least 3 x the V in D.C. value to assure safe operation.

Most filter capacitor failures are caused by inadequate consideration of ripple current rating. The ripple current on a well designed power supply will generally be 1.3 to 1.5 x the DC current. Using an underated capacitor for economy or due to ignorance will result in excess heating of the capacitors and premature failure. Always be sure your main filter capacitors have a RMS ripple current rating of at least 1.5 x the DC current at the lowest frequency of operation and the maximum operating temperature expected. The continuous operating voltage rating of the filter capacitor should be at least 1.5 x (V in nom. x 1.1) to allow for no load peak charging and should not exceed 2 x V in. nom. since a higher rated electrolytic would eventually reform to the operating voltage in any event.

The capacitance of the main filter is determined by the allowable ripple. For a worst case ripple of 5% RMS ωCRL for full wave rectification would be 15, therefore:

$$C = \frac{\omega 15}{RL}$$

C in farads

On supplies with current levels below 3 amps a higher ripple can be tolerated and offset by a higher DC voltage since low dissipation is not as important. In these cases, capacitance as low as 2,000 MFD per Amp is permissible providing the capacitor has adequate ripple current rating.

TRANSFORMER

Transformer design follows the usual basic design calculations but certain considerations must be given for game applications. Many video games operate in areas that are relatively open to the outside air. In parts of the country, ambient temperatures of 35°C. (96°F.) are not unusual for extended periods with occasional temperatures to 40°C. (105°F.) or higher. As mentioned previously, internal ambient temperature rises of 30 to 35°C. are quite common in video games. With a total ambient at the transformer of 70°C., a Class "A" (105°/C.) transformer would only be allowed to have a 35°C. maximum rise;with 80°C. only a 25°C. rise would be allowed. This would result in a large and costly transformer. It is strongly recommended that games' transformers be Class "B" (130°C.) impregnated. This permits designing to a maximum temperature rise of 60°C. for maximum life and lowest transformer cost. Short term rises above the rating will not affect life if offset by equivalent lower temperature operation for similar periods.

All games' transformers should have an electrostatic (Faraday) shield between primary and secondary to reduce capacitance and line noise feed through. This shield lead should be grounded to the transformer frame and the third wire ground from the line cord should be connected to the transformer frame. Adequate insulation must be employed between the primary and shield (as well as primary to core) to allow a 1-minute hypot test of 1500 VAC (2,500 Volts if used in Europe).

If it is anticipated that more than 25% of your games may be sold outside of the United States, it is generally desirable to employ parallel primary windings that can be connected in parallel or series for either 115V or 230V operation as well as enough steel for 50Hz operation. This will usually result in lower overall cost since stocking of two separate (115V & 220V.) transformers would not be necessary and changing them for specific applications would not be required.

Remember to allow adequate margin in your transformer design for the drop due to high ambient temperatures but also remember that too much margin adds even more heat to the system.

There are other reliability considerations for specific applications that should be considered:

1.) Inductive Load Protection: If the power supply is to operate inductive loads such as solenoids, relays or motors, inductive voltage spikes can raise the DC buss well above it normal level often momentarily reversing the voltage across the series pass transistor and causing destruction. This can be prevented by connecting a diode in reverse polarity across the pass transistor. The voltage spike is then directly bypassed and absorbed by the main filter capacitor.

2.) Reverse Polarity Protection: If multiple output supplies of opposite polarity are used, there is a definite danger of accidentally shorting the two opposing supply lines together during test and servicing. In many cases certain external circuit failures can tie the busses together. While this is almost guaranteed to cause at least one of the supplies to fail catastrophically, it can readily be prevented from damaging either supply merely by connecting a reverse polarity diode (of adequate capacity to handle the short circuit current of the opposite supply) across each supply.

3.) Overvoltage Protection: In the early days of transistorized supplies, failures were frequent due to the low quality of components available and the crude circuitry involved. Also the IC's and transistors used in the circuits being supplies by the power supply were very expensive. Overvoltage protection was nearly a

necessity on 5 volt supplies since the most common failure was shorting of the series pass transistor, which could more than double the voltage on the output buss destroying many load IC's.

Today, well designed highly reliable supplies such as those produced by Adtech Power have mean time between failures of 75,000 to 100,000 hours. Even the dual supplies exceed 50,000 hours. Field failure experience shows much less than 1% failure rates on the well proven standard supplies and under 0.1% in most video game applications. Also the cost of the load IC's has dropped considerably. In order to protect the load against even a 1% failure 100 overvoltage protectors would have to be purchased for each protection. Since the OVP costs from $5 to over $15 each depending on supply size, it is seldom economically justified unless we are protecting an extremely expensive circuit. There are some extenuating circumstances however. If multiple supplies of the same polarity are used and there is a likelihood of a higher voltage supply being tied to the 5V buss, an OVP may be justified. If a very low cost and crude power supply with a very low MTBF (under 10,000 hours) is used, OVP may be necessary although it would make more sense to put the cost of the OVP into building a more reliable power supply. If a new unproven power supply design is used, it would be wise to use overvoltage protection on early runs until a field failure history is established. If the repair cost of the board to be protected exceeds $500 (excluding the service call that would be necessary to replace or repair the failed supply) an OVP would generally be justified.

I have tried to cover the main factors that affect life and reliability of the power supply and the overall system. The rest of the power supply design will be found in the classical engineering texts. One strong caution however, all diodes are not the same. Surge current ratings can vary 5:1. All electrolytic capacitors are not the same; for a given capacitance and voltage, ripple current ratings can vary by more than 4 to 1 among different types and manufacturers. Be sure your components are well specified in all important parameters at the anticipated temperatures and know your vendors. In some cases, the selection of a good, reputable and reliable manufacturer will be more important than the adequacy of your design. Bargains in the critical areas can be extremely costly in terms of rework, field failures, lost sales, and reputation.

The last consideration is the build or buy decision. If you are going to build well over 10,000 supplies and have the necessary engineering expertise and manpower and the time, facilities, and equipment to thoroughly test the reliability of the supply under adverse conditions before it goes into production, it will usually be more economical to build your own supply. Be sure however that you really consider all costs when you make that decision. These

costs include the engineering, drafting and technical time (engineering costs generally will run $3000 to $5000 per design), redesign and retrofit cost, as well as the loss of their time on games design, purchasing and material control, freight costs, the warranty repair and freight costs, and additional supervision and manufacturing assistance costs as well as lost material labor and burden.

If the quantity of supplies will be less than 5,0000, it usually will be more economical to buy a standard power supply from a reputable manufacturer. For instance, Adtech Power buys most of their components in 50,000 to 500,000 quantity lots which greatly reduces component costs. There are no engineering costs since engineering was amortized over many customers for several years. Warranty costs are covered by the supply manufacturer. Tools, jigs, fixtures, test equipment, etc. do not have to be bought. Personnel training is eliminated. And most important of all, you are getting a well proven reliable design instead of a design which represents really experimenting on your product!


02 00:26 07

VI

A HOME VIDEO GAME CARTRIDGE CONNECTOR SYSTEM - INTERCONNECTION CONSIDERATIONS AND TECHNIQUES

ROBERT M. BOGURSKY
Product Engineering Supervisor
Burndy Corporation,
Norwalk, Connecticut

ABSTRACT

The Electronic Game market has recently begun its second generation with the introduction of the Fairchild Video Entertainment System. (See Figure 1). This system is the industry's first microprocessor-based ROM cartridge game. It revolutionizes TV Games by supplying the consumer with a microcomputer which extracts game information from a cartridge and routes it to a video processor chip for display on the TV screen. By changing cartridges, the user now has unlimited game possibilities. This differentiates this system from first-generation types which have fixed capabilities.

By placing a cartridge containing a printed circuit board and associated electronic components in the consumer's hands, game manufacturers are now presenting electrical connector engineers with some new and challenging requirements. As other products evolve out of the widespread use of microprocessors, and programming possibilities increase by giving the consumer a printed circuit board in a cartridge, a new class of electrical connectors will likely emerge.

Standard printed circuit board connectors currently available do not satisfy all the requirements of a consumer connector. Design conflicts exist between the needs for ease of use, long term reliability after many mating cycles, resistance to abuse, and low cost.

It is the intent of this paper, therefore, to review the basic requirements and problems associated with providing a consumer-operated printed circuit board connector. Furthermore, it describes the interconnection techniques Burndy used in the Fairchild Video Entertainment System Cartridge Connector to show how these problems were solved to achieve a successful system. The cartridge system and rotating interconnection feature described in this paper were conceived and designed by the Exetron Division of Fairchild, Inc.

The technology and materials used to provide reliable connections after many mating cycles at the printed circuit board interface, as well as the Gas Tight High-pressure base metal connections used elsewhere in the system, are discussed.

Fairchild's Video Entertainment System.

Figure 1 - FAIRCHILD Video Entertainment System

TEXT

The mating of a printed circuit board and a card edge connector is a very common occurrence in the world of electronics. Engineers and technicians are routinely careful to respect the vulnerability of the expensive hardware they handle. On the other hand, the consumer cannot be expected to do so.

The average consumer's exposure to electrical connections is limited to line cord plugs and wall receptacles, accessory cord pin and socket connectors in hand held appliances, and phone jacks. These are all ruggedly built to withstand consumer abuse, as contrasted by a p.c. board with delicate electronic components.

Video Game engineers, therefore, have a need to protect the programming boards consumers will use in second generation games. The cartridge concept appears to be the direction most games will utilize. Cartridges are already familiar to the consumer for use in 8-track and cassette tape decks and will, therefore, be readily accepted for Video Games. They also provide the required protection from abuse.

In order to understand how cartridge operated games create a need for a new class of connector, we must first examine the requirements for these connectors and then look at the standard connectors available. The basic requirements are:

A. EASE OF USE
B. PROTECTION FROM ABUSE
C. PROPER ALIGNMENT
D. ELECTRICAL STABILITY
E. MANY MATING CYCLES
F. LOW COST

Two types of p.c. board connectors are generally considered:

1. STANDARD CARD EDGE CONNECTORS
2. ZERO INSERTION FORCE CARD EDGE CONNECTORS

When we evaluate these connectors against the basic requirements for their use in Video Games, we find that each type lacks all the desired qualities. Let us explore this further:

A. EASE OF USE

Standard card edge connectors are simple for the consumer to use since they require only a push-in or pull-out action of the cartridge. (See Figure 2) Zero insertion force connectors use the same push-in action, but they also require actuation of the contacts to mate them with the p.c. board, and deactuation to remove the board. (See Figure 3) This secondary action could be accomplished by a cammed slide, or pushbutton, or rotating knob.

When many contacts are required, standard card edge connectors are unsuitable because mating forces get too high. A 15 position 30 contact double sided card edge connector, for example, requires about 12 pounds insertion force in noble contact metal systems, and up to 20 pounds in non-noble systems. Since Video Games will be used by children, if many contacts are needed, zero insertion force connectors are preferred.

• Ease of Use

Standard Card Edge Connector

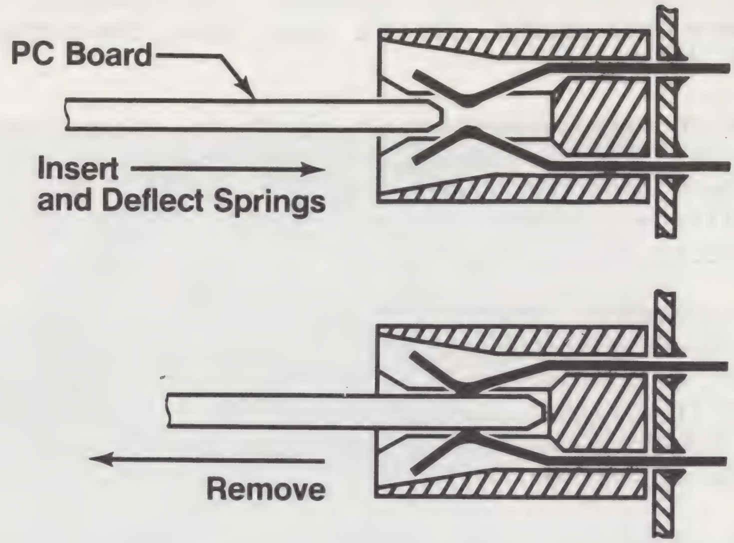


FIG. 2

• Ease of Use

Zero Insertion Force Card Edge Connector

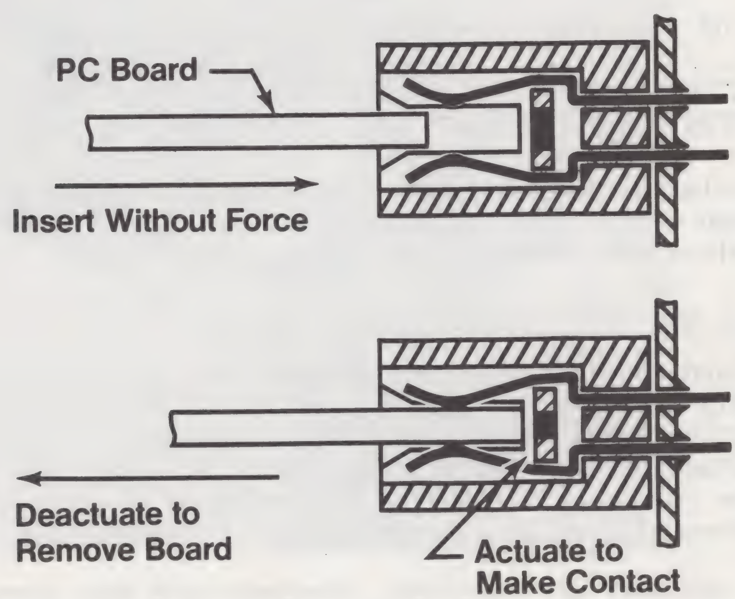


FIG. 3

B. PROTECTION FROM ABUSE

The contact springs in standard card edge connectors are deflected by the p.c. board upon insertion. Chamfered boards are commonly used to lower insertion forces, protect the springs from buckling loads, and minimize wear. These chamfers are usually not controlled well, increasing the potential for damage. They also add additional costs to p.c. board manufacture.

Zero insertion force connectors are less prone to damage since the contact springs do not contact the p.c. board until after the board in inserted in the connector. However, another complication is present if a zero insertion force connector is used. This type of connector system is not as straight forward for a consumer to use because it must be actuated and deactuated. Extra care must, therefore, be taken in the design to prevent the cartridge from being inserted or removed without using the actuator. Protection against damage to the connector or actuating mechanism must be provided for since attempts will surely be made to insert or remove the cartridge when the actuator is in the wrong position. Common techniques prevent insertion of the cartridge when the contact springs are in the actuated position. They also lock the cartridge in place preventing its removal in the actuated state. This detail is easily overlooked by the user, and could lead to improper handling.

C. PROPER ALIGNMENT

This requirement is the easiest to satisfy in either type connector. When contact centerline spacings are .100 inch or greater, normal manufacturing tolerances provide proper alignment by controlling the clearance between the p.c. board and connector card slot, or between a key in the connector and a slot in the board. These methods are preferred for manufacturability rather than designing for cartridge alignment to the case, and ultimately the p.c. board to the connector.

D. ELECTRICAL STABILITY

Electrical stability is also a very simple requirement to fulfill with either type of connector. Based on current technology, either a low contact force system would be used with noble metal contact and p.c. board finishes, or a high contact force system with a non-noble metal finish. Gold is most commonly used with minimum normal forces of 50 or 100 grams, and nickel is currently under evaluation by some manufacturers, for higher force systems. Higher forces are required in non-noble metal systems to break through insulating oxide films which form on the contact surfaces. Standard card edge connectors are preferred when nickel is considered as a contact metal since the relatively long wiping distance is useful in cleaning the contacts and p.c. board pads. When zero insertion force connectors are used, the wiping distance is considerably smaller, or nil, and gold or gold alloys are more commonly used. They are essentially immune to corrosion in a home environment if they are sufficiently thick and properly applied.

The choice of which system is appropriate is influenced most by the electrical characteristics required. In dry circuit applications where

under 50 millivolts are used and contact resistances of the order of 10 to 100 milliohms are required, gold is specified. When voltages are in the 1.0 volt or higher range, and resistances can be in the order of 5-10 ohms, nickel is considered. High voltages break through most insulating films to give adequate performance.

Even if all of the above requirements could be fulfilled by a standard or zero insertion force edge connector, selection would still not be an easy task because of the next requirement of a cartridge connector.

E. MANY MATING CYCLES

Video Games have reawakened the need for connectors that are continually used. While most edge connectors are recommended for use in the 100 to 500 cycles range, game engineers are now specifying 2,000 to 5,000 cycles as a minimum acceptable requirement. It is this requirement that causes much concern in the industry - and is leading to a new class of connector specifications. Presently available high force systems cause considerable wear, even on hard nickel surfaces. In gold based systems where forces are lower, however, wear also occurs since gold is relatively soft. Heavier than standard gold thicknesses would help solve the dilemma, but the following essential consumer product requirement would not be met.

F. LOW COST

Low cost must be evaluated two ways:

1. Purchased connector cost
2. Installed connector cost

In both respects, standard edge connectors are preferred. Zero insertion force connectors are initially more costly since they contain an additional actuating mechanism. They also cost more to fit into game packaging since the mechanism complicates game assemblies and usually requires extra parts.

We see, therefore, that design conflicts exist in chosing a Video Game connector:

STANDARD CARD EDGE CONNECTORS ARE INADEQUATE WHEN

1. Number of contacts are large.
2. Abuse is anticipated.
3. Noble metals are required.
4. Many mating cycles are specified.

ZERO INSERTION FORCE CONNECTORS ARE INADEQUATE WHEN

1. Simplicity of use is of primary concern.
2. Initial and installation costs are primary.

Since there is a need for improvement in the above techniques, new types of connectors are being sought after by Video Game engineers.

In the first Video cartridge game to reach the market, Fairchild Exetron Division established the need for a rotating connector to achieve their goals. The techniques Burndy incorporated in the design of this connector are discussed in the remainder of this paper. Specifics concerning Fairchild's mechanism design will not be discussed in detail, since it is the intent of this paper to focus on the connector considerations and technology involved rather than specific design or manufacturing preferences of the game or connector. The following, therefore, is only a brief description to introduce the basic system and establish the connector requirements:

CARTRIDGE CONNECTOR SYSTEM

In the Fairchild Video Entertainment System a cartridge is inserted with a straight-in motion through a swing away protective door in the console. As the cartridge travels through a chute assembly, bosses cam away the cartridge's protective door to reveal the programming p.c. board. The p.c. board then enters the card slot in the connector and is aligned by the connector key and p.c. board slot. (See Figure 4)

As the cartridge travels further, the p.c. board clears the contact springs and bottoms at the rear of the card slot in the connector while rotating the connector backward. The contact springs simultaneously rotate upward to meet the p.c. board, and the cartridge locks in place.

The connector was originally preloaded forward 15 degrees by extension springs before the cartridge was inserted. In the locked-in position of the cartridge, the connector is angled 15 degrees backward, giving 30 degrees total travel of the connector. This travel is against the force of the preload springs, which cause the rear of the card slot to rest against the edge of the p.c. board.

To remove the cartridge, a bar is depressed which unlocks it from the chute. The cartridge is then automatically ejected since the preload springs cause the connector to push backward on the p.c. board.

Since a rotating connector was required, conventional wave soldered contacts could not be used to make connection to the mother board in the console. Instead, flat cable was used to achieve a flexible transition. (See Figure 5) The flat cable interconnects with the mother board through two Burndy FLEXLOK™ connectors which use separable Gas Tight High-pressure (GTH) contacts. The FLEXLOK™ connectors are wave soldered to the mother board prior to cable insertion. In the cartridge connector, similar flat cable connections are made with GTH contacts.

Rotating Cartridge Connector

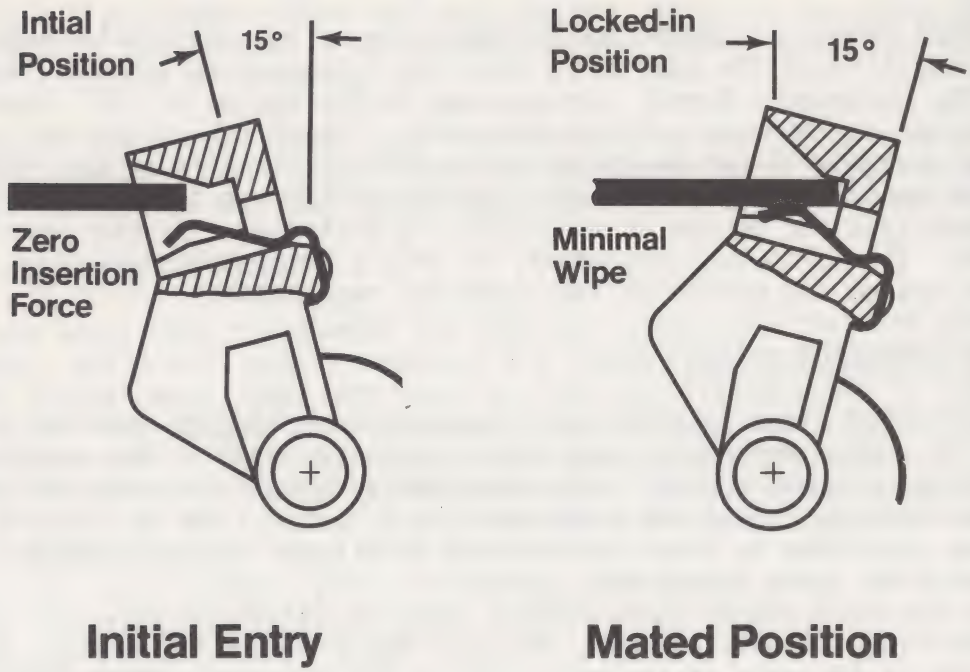


FIG. 4

Rotating Cartridge Connector System

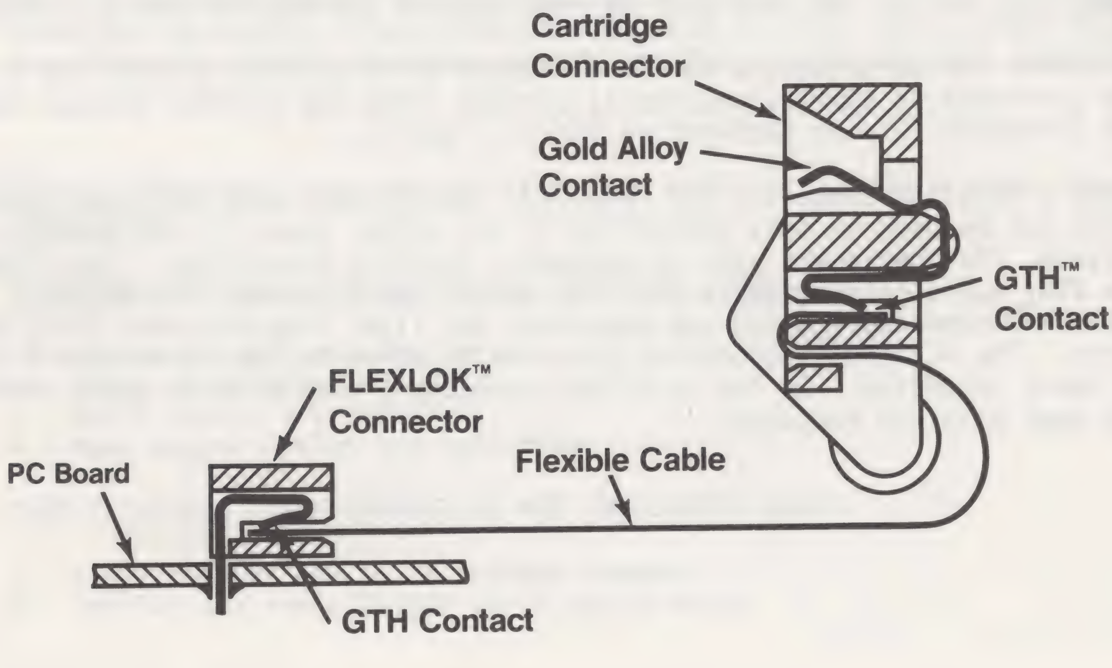


FIG.5

These GTH contacts will be described further in this paper; but first let us examine the connector system in more detail against the basic requirements previously established.

The system provides a modified zero insertion force connector with the following features and benefits:

A. EASE OF USE: Since insertion is straight-in, and actuation is simultaneous with insertion without requiring a separate action; insertion force is essentially independent of contact force and the number of contacts, and is predetermined by the return springs; removal is automatic by depressing an eject bar.

B. PROTECTION FROM ABUSE is inherent in the design since the connector is recessed deeply in the console behind a protective door; the p.c. board pads are behind a protective door; the connector cannot be in an actuated position when the cartridge is inserted; and the cartridge cannot be inserted upside down. If the locking device is overcome by pulling hard on the cartridge, no damage occurs and the connector returns to its proper position. To withstand insertion forces the connector was molded of a strong glass filled thermoplastic polyester material.

C. PROPER ALIGNMENT is assured by a key in the connector and a slot in the p.c. board, both with generous lead-in chamfers.

D. ELECTRICAL STABILITY is achieved by utilizing a gold alloy inlay material for the contact surface of the spring, and by maintaining adequate contact normal forces.

E. MANY MATING CYCLES are obtained from the rotating zero insertion force type action which minimizes wear by creating a very short wipe distance of the contact springs; low, well controlled contact forces; use of a relatively hard gold alloy inlay material on the contact spring; and a fine grain phosphor bronze spring material to prevent fatigue.

F. LOW COSTS are realized by using a gold alloy inlay to minimize gold usage on the contact spring; tin alloy plating for the GTH contact end of the spring that connects the flat cable; fast molding thermoplastic polyester material for the connector housing; and a design that permits automatic machine assembly of the contacts into the housing.

System installed costs were kept low by providing GTH connections to the flat cable which require only a simple push type insertion, as opposed to other designs which require soldering of discrete wires. The separable GTH contacts also permit easy removal of the connector from the console without desoldering, should replacement be necessary.

Since conformance to the basic design requirements has been demonstrated, we will now review the contact materials and technology used in this connector system. The p.c. board mating interface will be described in detail first, with supporting test data, and then the flat cable connections will be discussed briefly.

THE CARTRIDGE CONNECTION

THE CONTACT SURFACE

The choice of a contact material was based on the need for high reliability for introduction of the first second generation game, and the potential use of dry circuit voltages. Considerable concern for the use of nickel in this application was present to preclude its use, based on prior research conducted at Burndy. In a 1972 report entitled "Contact Properties of Nickel Containing Alloys", nickel was mated with a gold probe at various force levels after exposure to several environments. The results in Figure 6 indicate that the long term effect of sulfur dioxide and humidity type exposures is to produce very high contact resistances. A gold system was therefore recommended for the contact surface.

The specific alloy selected for the contact spring mating surface contains 94% gold and 6% nickel. As an inlay, it has a hardness of 200 KHN minimum before forming, as compared to the 130 to 200 KHN hardness of electroplated hard gold found in most connector applications. The alloying of nickel and gold reduces the tendency of the gold to smear to stick and forms an excellent contact material where increased resistance to wear is required. A thickness of 50 microinches minimum was specified.

To evaluate the integrity of the 94 Au/6 Ni inlay after forming, microscopic examinations and porosity tests were conducted. Examination of cross sections through the contact spring showed excellent adhesion of the gold alloy to the nickel underlay carrier, and of the nickel to the phosphor bronze spring. (See Figure 7). Nitric acid vapor exposure for one hour exhibited acceptable pore densities when compared with standard electroplated gold contacts.

CONTACT FORCE

In designing for minimum wear, contact normal forces were kept low. To determine spring performance, normal force and permanent set vs. deflection characteristics of the contacts were measured with equipment having a very sensitive force transducer and micrometer stage. The results in Figure 8 show that within a design range of .020 to .050 inches tolerance range for spring deflection, 90 to 210 grams normal contact force is initially obtained. The permanent set that occurs at high deflection levels serves to reduce maximum forces at tolerance extremes. By comparison, standard gold system edge connectors work in a range of 50 grams minimum in stationary applications, and 100 grams minimum where vibration and mechanical shock is anticipated, to maximum forces of 300 to 350 grams. This connector, therefore, utilizes springs with appropriate minimum forces and substantially lower maximum forces, which aids in reducing wear and increasing the number of permissible mating cycles.

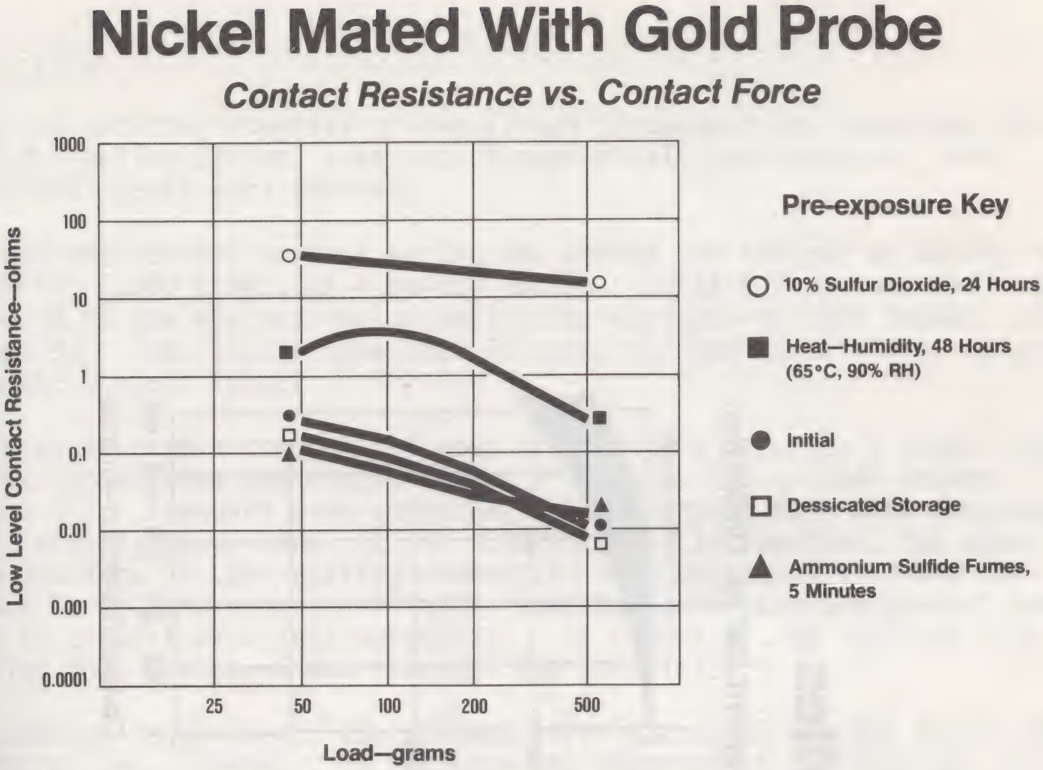


Figure 6

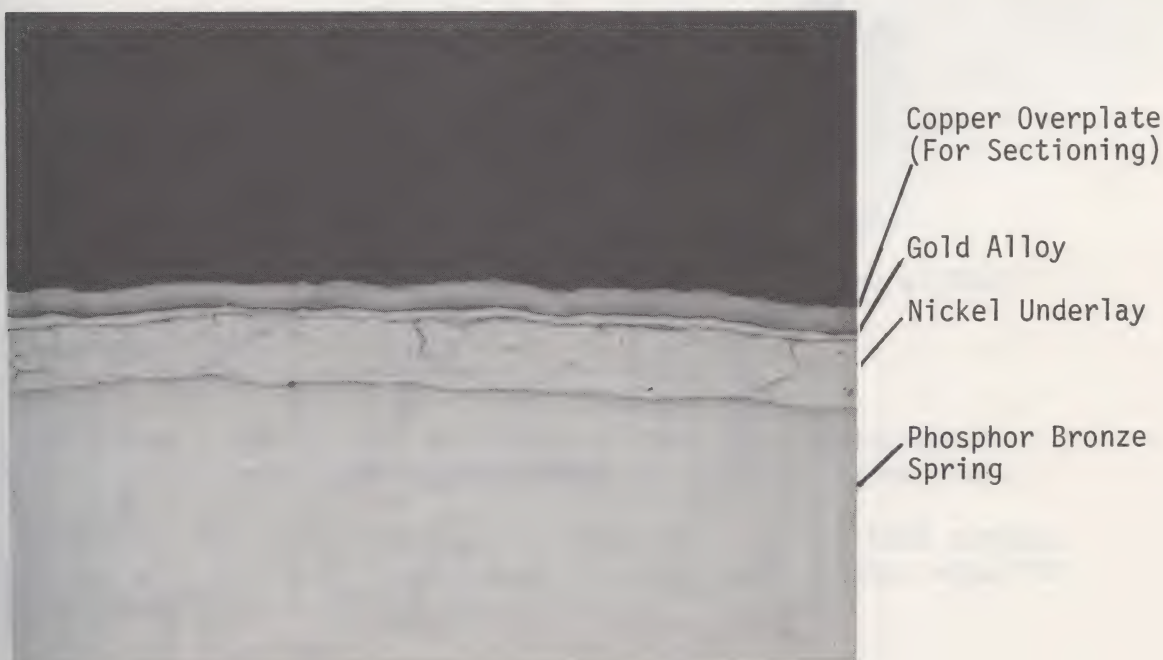


Figure 7. Cross Section Thru Contact Spring, 750X

Spring Properties

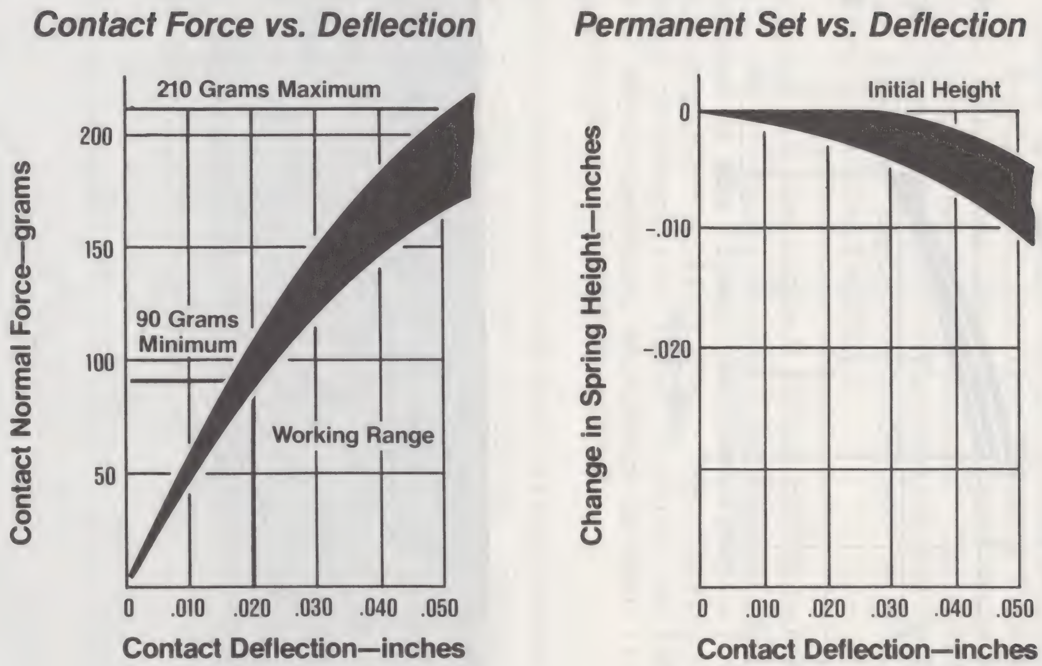


Figure 8

LIFE TESTS

To prove out the integrity of the system throughout its required life of 3,000 mating cycles, a series of mechanical, environmental, and electrical tests were devised.

The phosphor bronze contact spring was tested for fatigue by mating the connector 5,000 times, as a safety factor. Contact force was periodically measured at the minimum design deflection distance of .020 inches. (See Figure 9). The results show that 60 grams minimum is obtained, assuring adequate contact force.

Microscopic examination of the wear track on the p.c. board after 1,000 cycles showed that the wiping distance is only .030 to .040 inches. (See Figure 10). Standard edge connectors, by contrast, have wear distances which usually range from .125 to .250 inches. In addition, the short wipe distance of the rotating connector, in combination with the low normal forces and a hard gold alloy surface, permitted the contact surface to exhibit excellent durability. In Figure 11, we see that life cycling does not cause wear through the gold inlay.

As a design requirement, the average life of a cartridge was set at 300 to 500 cycles. However, to increase the severity of the testing, as a safety factor, and realizing that unequal cartridge usage would occur in actual practice, the following test sequence was performed:

ENVIRONMENTAL AND ELECTRICAL LIFE TEST SEQUENCE

a. Contact Resistance (20 Mv. at 10 Ma.)
b. 1,000 Mating Cycles
c. Contact Resistance
d. 48 Hrs. Heat and Humidity Cycling, Unmated (65°C, 95%RH)
e. Contact Resistance
f. Replace Cartridge Every 1,000 Cycles and Repeat a. thru e. Four Times for a Total of 5,000 Connector Cycles
g. Contact Resistance

Heat and humidity cycling was incorporated as an accelerated aging process to simulate consumer use and long time storage before reuse.

The results of this testing appears in Figure 12. We see that contact resistances are essentially unaffected at dry circuit levels, attesting to the acceptability of the system.

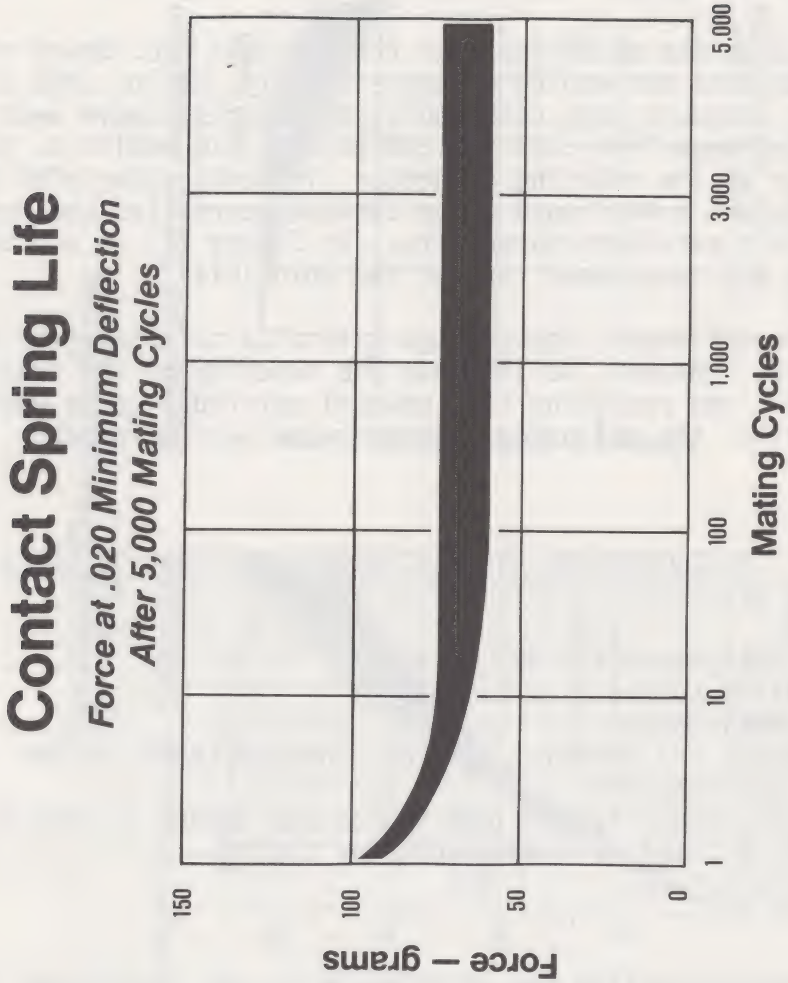

Contact Spring Life
Force at .020 Minimum Deflection
After 5,000 Mating Cycles
Force — grams
150
100
50
0
1
10
100
1,000
3,000
5,000
Mating Cycles

Figure 9

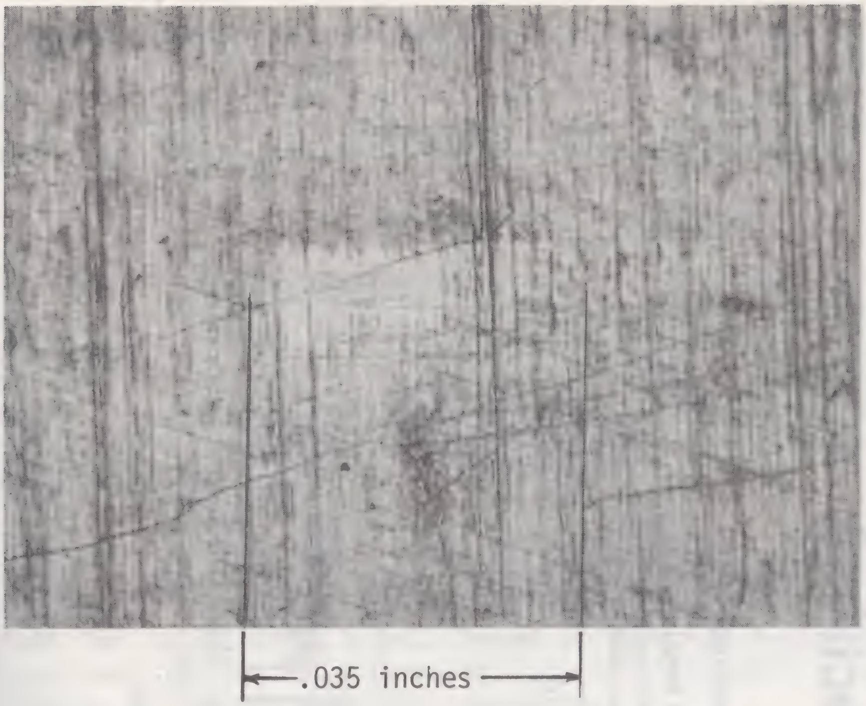


Figure 10 - Wear Track on P. C. Board
After 1000 Mating Cycles, 50X

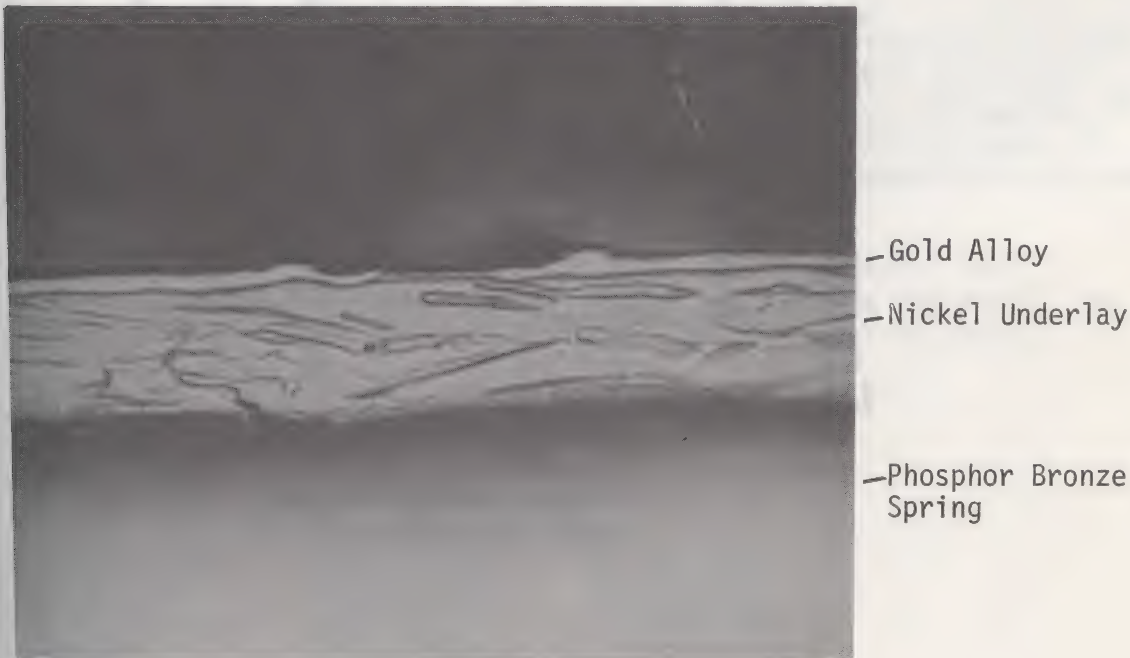


Figure 11 - Cross Section thru Wear Track
After 5000 Mating Cycles, 1500X

Environmental and Electrical Life Test

Resistance After Environmental Exposure

Test Sequence *(5 Times)*

1000 Matings per Cartridge
48 Hours Heat and Humidity, Unmated

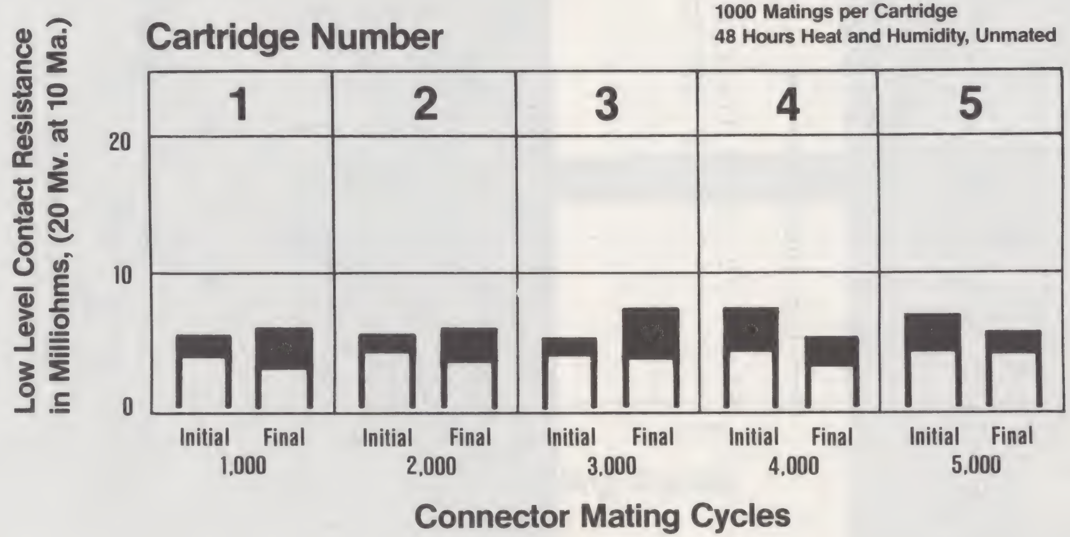


Figure 12

The main purpose of this paper was to focus on the cartridge connection aspects of a video game. In doing so, a rotating connector was described which required a flat cable connection as part of the overall system. (See Figure 5). For completeness, and because of its unique technology, a brief description of this interconnection technique is also offered.

THE FLAT CABLE CONNECTION

In "The Successful Utilization of Dry Circuit Base Metal Contacts" by Garte and Diehl, a low cost GTH contact with tin-alloy plating is described. This high pressure contact uses a sharp edge, much like that on a wire wrap post, to penetrate oxide films on a solder plated p.c. board. (See Figure 13). The penetrating topography creates a gas tight joint which is impervious to ingress by corrosive gases in the atmosphere.

In place of a p.c. board, the Burndy cartridge connector uses flat cable to mate with GTH contacts. The cable is inserted through a slotted section in the housing to provide strain relief. It is then plugged into the connector as a p.c. board is inserted in an edge connector. The other end of the cable is installed into FLEXLOK™ connectors having similar GTH contacts in the same manner.

Although most GTH connector designs use a non-wiping mating action to increase the number of permissible mating cycles, the largest number of GTH contacts are found in I.C. socket receptacles. These require only a few mating cycles and use a wiping action like the flat cable connection used in the FLEXLOK™ and cartridge connectors.

A simple test designed for use in determining the gas tightness of tin-alloy plated contacts was used to evaluate the flat cable connections. It consisted of a one hour exposure to nitric acid fumes followed by 15 minutes exposure to ammonium sulfide fumes. The results in Figure 14 show that the contact interface was not attacked by these corrosive agents and that the joints are gas tight.

In addition to extensive product testing in the laboratory, the reliability of GTH contacts has been established by the successful use of over a billion contacts in service during the last four years.

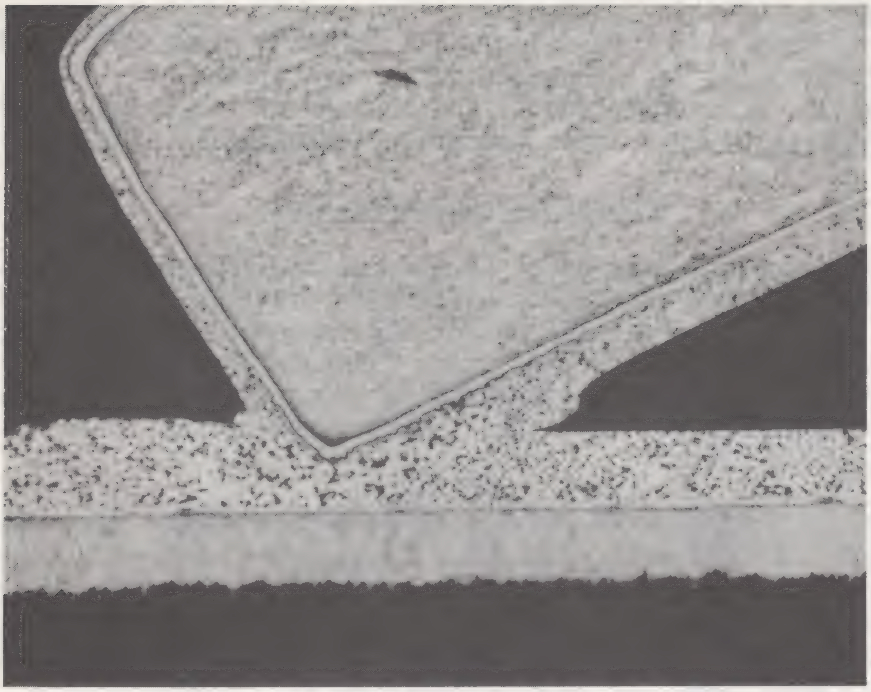


Figure 13 - Cross-section of GTH Contact Interface, Tin-Alloy Plated System, 250X

Flat Cable Connection Evaluation Gas Tightness Test

1 Hour of Nitric Acid Fumes Followed by 15 Minutes of Ammonium Sulfide Fumes

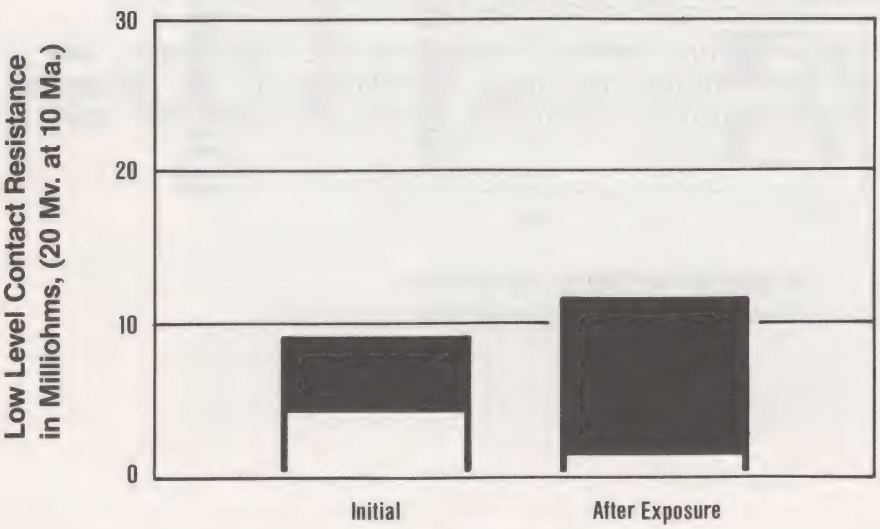


Figure 14

CONCLUSION

We have analyzed the requirements for a cartridge connector for video games and seen how existing connectors fall short of meeting these requirements. A need was thereby created for a new class of connectors.

To satisfy this need for the first cartridge operated video game, a new rotating type connector was developed. This connector incorporated the most up to date technology to satisfy all of the basic requirements established. It was extensively tested to prove out its integrity, and is currently in production.

ACKNOWLEDGEMENT

The author wishes to thank Ronald Smith of the Exetron Division of Fairchild for his guidance during the development of Fairchild's rotating connector concept.

REFERENCES

1. S. M. Garte, A. Solomon, D. Osborn, "Contact Properties of Nickel Containing Alloys", Sixth International Conference on Electrical Contact Phenomena, Chicago, Illinois, 1972.

2. M. D. Lazar, S. M. Garte, R. P. Diehl, "A Low Cost, High Reliability Separable Connector Contact Concept", IEEE Intercon '73, New York, New York, March 30, 1973.

3. S. M. Garte, R. P. Diehl, "The Successful Utilization of Dry Circuit Base Metal Contacts", Ninth Annual Connector Symposium, Cherry Hill, New Jersey, Oct. 20, 1976.


Map

ELECTRONIC GAMES: TECHNOLOGY DRIVES MARKET EXPLOSION

JEFF D. MONTGOMERY
Vice President
Gnostic Concepts, Inc.
Menlo Park, CA

The rapid evolution of microprocessors and other LSI circuits, plus new display devices and other components, will drive a large and rapidly expanding market for electronic games over the next four years. The growing complexity of integrated circuits, combined with their plummeting costs as production volume accelerates, will make available a wide variety of increasingly complex games at declining prices.

The introduction and promotion of new and updated games will proceed across a broad front, from throw away consumer items, priced at a few dollars each, to major revenue producing games at several thousand dollars each. These games will fall into three basic price ranges:

- Consumer expendable units, $10-100 each retail, typically single game, not reprogrammable

- Home entertainment centers, $100-500 retail; reprogrammable for a variety of games, and also providing non-game functions

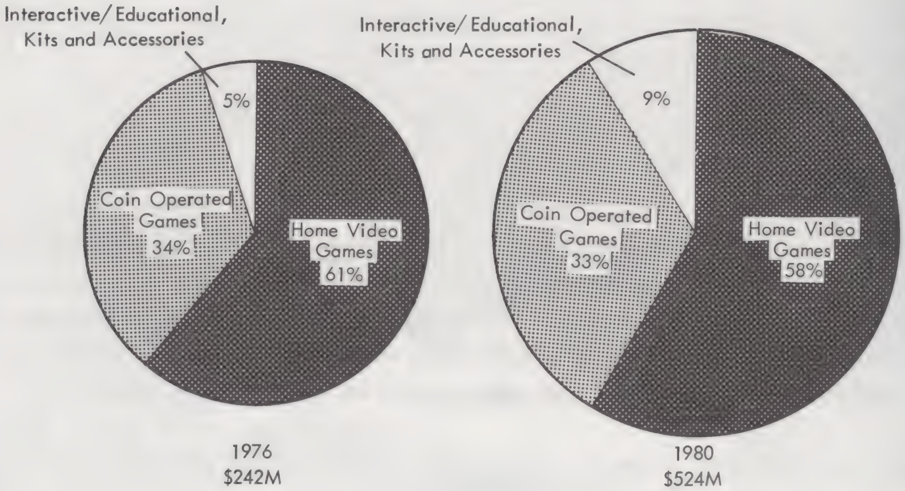
- Commercial games, $500-3,000 each, generally coin operated and revenue producing.

The total US domestic production of electronic games in 1976 was $242 million, as shown in Figure 1. This will more than double, growing at an average annual rate of over 21 percent per year to reach $524 million in 1980. Some of this production will be exported. Exports, however, will be exceeded by imports, including games assembled offshore by US manufacturers. The US market, therefore, will be slightly larger than US domestic production, as discussed later in this paper.

Home video games dominated production in 1976, with a production value of $148 million, 61 percent of the total. Coin operated games, primarily video type lounge games, represented total production of $83 million. The shift in these ratios will be minor over the next four years. The most rapid growth will be achieved in interactive and educational games, plus kits and accessories, representing a small share of 1976 production but almost doubling their share by 1980.

Jerry Eimbinder of Electronic Engineering Times with Nolan Bushnell, board chairman of Atari.

FIGURE 1
ELECTRONIC GAMES U.S. PRODUCTION*



* Excludes Offshore Assembly

VIDEO LEADS COIN OP Games incorporating a video display, using a CRT, dominated 1976 production of commercial games, accounting for 69 percent of the total, or $57 million, as noted in Figure 2. Electronic pinball games also are finding wide acceptance. Electronic blackjack, stud, dice and other games are beginning to penetrate casino operations. Casino and pinball game production will expand slightly more rapidly than video skill games over the next four years. The overall production of commercial games will more than double, expanding at a 20 percent annual average to reach $172 million in 1980. Microprocessors will be widely used in these advanced games.

STAND ALONE HOME VIDEO TAKEOFF Nearly all 1976 production of home video games consisted of add on kits for attachment to existing television receivers. This situation will shift drastically over the next four years, however. A rapidly increasing share of this market will be served by stand alone units which incorporate the basic TV receiver and a variety of games in the single home entertainment center. The stand alone share of the home video market will explode from a negligible 1976 position to 43 percent of production, $132 million, in 1980. These games typically will incorporate microprocessors, and will be designed for reprogramming by plugging in new printed circuit cards, tape cassettes or other media. The add on kit production will remain relatively constant in dollar value, increasing from $145 million in 1976 to $175 million in 1980, while the add on share of home video games drops to 57 percent, as noted in Figure 3. Stand alone home video games, in addition to entertainment

FIGURE 2
COIN OPERATED ELECTRONIC GAME U.S. PRODUCTION

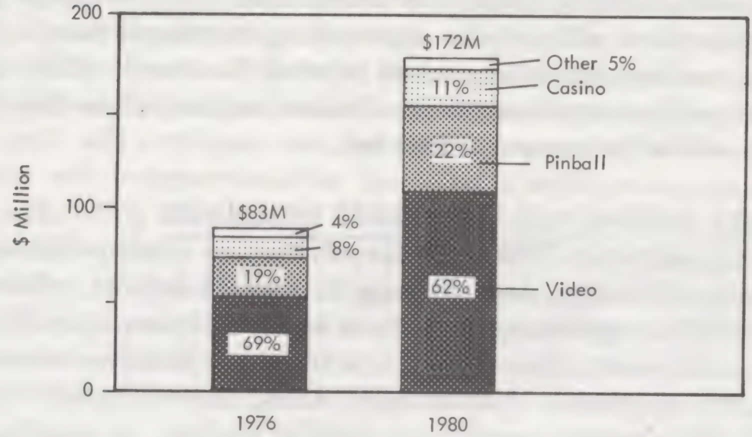
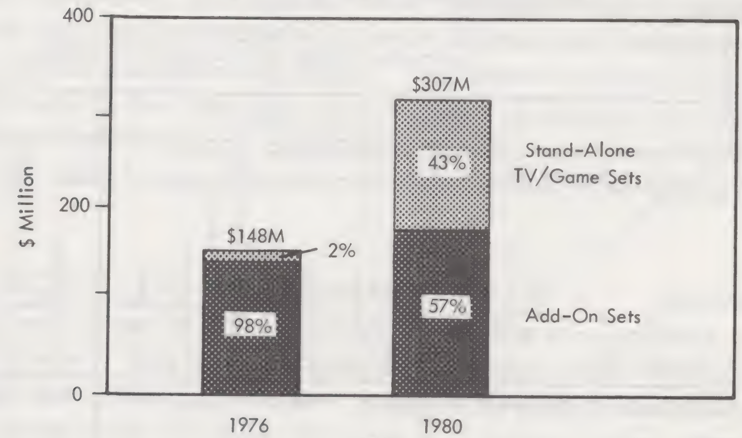


FIGURE 3
HOME VIDEO GAMES, U. S. PRODUCTION



functions, in many instances will evolve to encompass nonentertainment functions. By incorporation of a keyboard plus logic, memory and I/O circuits, a home computer can be incorporated in the same basic unit. Cable television networks will extend two-way communication capability to this basic unit, although growth in communication applications will only be approaching its takeoff point by 1980. The traditional television receiver producers such as Admiral/Rockwell, RCA, Zenith, Magnavox/NAP and Quasar will monopolize the stand alone market, often drawing on LSI capabilities elsewhere within their own corporation.

SHIPMENTS OUTRACING CONSUMER PURCHASES The total US absorption of electronic games in 1976 was $261 million, as noted in Table 1. This includes the US domestic production, less US exports, plus US imports. Over two thirds of these imports, in 1976, were from the offshore assembly operations of US companies. Not all of these shipments, however, found their way into the hands of consumers or commercial game operators. A substantial share, $44 million or 17 percent, consisted of buildup in the pipeline inventory on retailer shelves, in warehouses and other inventory. The net end market, therefore, was $217 million in 1976. Pipeline build up will peak in 1978, and decline gradually thereafter. The end market in 1980, therefore, will be $584 million, slightly in excess of total shipments at the wholesale level.

TABLE 1
ELECTRONIC GAME US CONSUMER PURCHASES

Type of Game / Product Flow	1976				1980			
	Coin Operated	Home Video	Interactive/Educational, Kits and Accessories	Total ($M)	Coin Operated	Home Video	Interactive/Educational, Kits and Accessories	Total ($M)
US Production for World Market	83	148	11	242	172	307	45	524
US Exports	14	11	1	26	41	28	9	78
US Imports*	2	43	-	45	7	97	20	124
Net US Absorption	71	180	10	261	138	376	56	570
Pipeline Absorption	3	39	2	44	4	(15)	(3)	(14)
Consumer/Operator Purchases ($M)	68	141	8	217	134	391	59	584

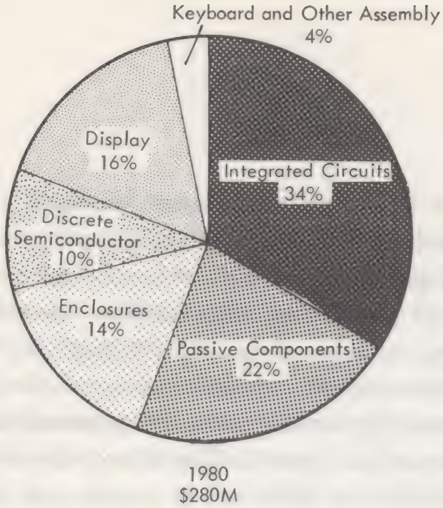
*Includes offshore assembly imported by US companies

GROWING COMPLEXITY OF GAMES The availability, at low cost, of microprocessors and a wide range of special LSI circuits will encourage growing complexity of electronic games. The first generation of games was typified by the ping-pong game, permitting only a single format of play and not providing adjustability for different skill levels. The second generation of games, now phasing into production, provides adjustment of games parameters. Some of these permit reprogramming to play different games. This evolution toward greater adjustability and greater programmable variety within a single unit will continue over the next four years. The stand alone home games units increasingly will incorporate other functions in addition to games and basic television viewing, including computation and data processing. Most electronic games to date have been electronic versions of popular sports, card games and similar well established concepts. Future electronic games increasingly will introduce unique concepts that will stand or fall on their success in appealing to the imagination and interest of consumers. Consumers will become more sophisticated in their use of games, and will create markets for more difficult games based on unique concepts.

DISTRIBUTION CHANNELS ARE VARIED The distribution channels most appropriate for electronic games vary widely, depending on the type of game. Coin operated games typically are owned or rented in quantities of dozens to hundreds, by operators who place and service them. This distribution typically is direct from the manufacturer to the operator. These channels are dominated by the old line established electromechanical game producers, and very difficult for newcomers to penetrate. Home games, conversely, move through traditional appliance channels to consumers: major department stores, discount houses and specialty stores. The share of games which move direct from the manufacturer to the consumer will increase drastically by 1980, based on catalog order firms and direct mail promotion. Small, new competitors in electronic games will find the establishment of suitable distribution to be among their biggest problems.

INTEGRATED CIRCUITS LEAD COMPONENT DEMAND Integrated circuits, in 1976, constituted 47 percent of all component value in electronic game production, as outlined in Figure 4. This includes special LSI game chips, microprocessors, memory and logic devices and other ICs. Passive components such as resistors, capacitors, printed wiring, connectors and cable held the next largest share, 22 percent or $28.3 million. The IC share will drop to 34 percent by 1980, although their total value will expand from $58.4 million to $93.5 million over the forecast period. The display share will grow rapidly, from 6 percent to 16 percent, as home games increasingly are built as stand alone units.

Enclosures represent a significant share of component value, 13 percent in 1976. Coin operated games typically use rugged, wood cabinets costing from $75 to several hundred dollars. Home stand alone games also will use relatively expensive cabinets.



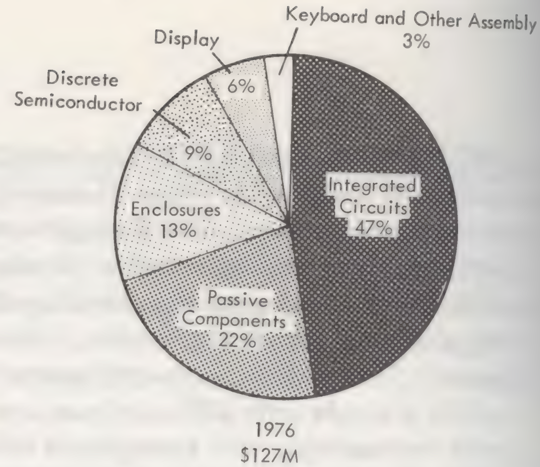


FIGURE 4
COMPONENT USE IN U.S. ELECTRONIC GAME PRODUCTION

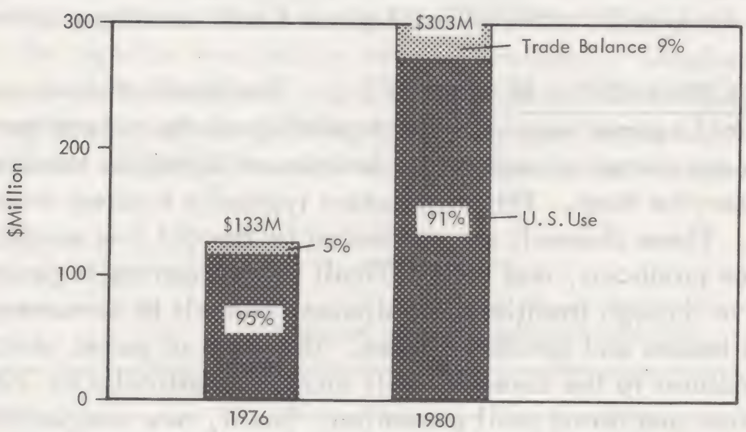


FIGURE 5
ELECTRONIC GAME COMPONENTS U.S. PRODUCTION

<u>COMPONENTS MOSTLY US PRODUCED</u> Nearly all of the components used in US game production are domestically produced. Imported components used in 1976 game production totaled less than $1 million, while game components valued at $8 million were exported. The total US production of electronic game components will expand to $303 million by 1980, as outlined in Figure 5, and 92 percent of these will be used in domestic game production. Over $21 million of ICs will be exported for foreign game production in 1980.

These market forecasts are preliminary conclusions from an extensive market research study being made by Gnostic Concepts, Inc. The conclusions are based upon extensive interviews of game component producers, manufacturers of electromechanical and electronic games, distribution channel participants and others knowledgeable in the field. The production of games was related to component production by computerized input/output analysis which forces internal consistency of data. Research for this program will continue through February, 1976, leading to a detailed final report.

THE TRAZOR (TM) — A NEW INPUT DEVICE

WILLIAM PEPPER, JR.
President
Peptek, Inc.
Bethesda, MD

ALAN J. RIDER
President
Reston Consulting Group, Inc.
Reston, VA

Figure 1. People find the Trazor a more exciting way to play video games.

Introduction

A new kind of man-machine interface device called the Trazor (TM) gives two-axis output signals when a special control surface is touched with a finger. It has no moving parts and the control surface can be part of the plastic housing of a product.

People who have played video games with the Trazor and with conventional potentiometers overwhelmingly prefer the Trazor, describing it as "more fun" or "more exciting" (see Figure 1). Equally important, it offers the game manufacturer freedom from the reliability problems of potentiometers and joysticks.

(TM) A trademark of Peptek, Inc.

The main emphasis of this paper is on the Trazor as an integral part of video games. The paper discusses human engineering aspects of the Trazor, points out how it improves the reliability of video games, and suggests some areas of potential application other than games. It explains the principle of operation. Some background information is given on the Trazor's origin and development, and the major technical problems that had to be overcome are described. Manufacturing techniques are discussed and cost estimates given for quantity production.

Human Engineering Aspects of the Trazor

A Trazor is the most straightforward way to control something -- it's almost as easy as pointing at it. Once you see the Trazor, it seems so obvious you wonder why you never saw one before. The control surface of the Trazor, when used as an input for a video game, is a scaled linear model of the playing area. Touching it causes the paddle, or other game feature, to appear at the corresponding place on the screen. This simplicity and directness of function appeals greatly to people. We have sampled the reactions of about 50 people, some casually and some under more controlled conditions, comparing the Trazor with the standard potentiometers of a Super Pong game. So far we have not found anyone who prefers the potentiometers.

Observation reveals that the Trazor does not produce any dramatic improvement in game-playing ability, but is much easier to "get the hang of." Instead of just trying to intercept the ball, players soon take to aggressively hitting it, and their involvement in the game increases. After a little experience, children start playing tricks such as letting a slow ball go past the paddle and then hitting it from behind.

People have individual ways of using the Trazor. There are two ways that they orient it for playing Pong: either they place the side of the Trazor corresponding to the net away from them, so they are "facing the net," or they line it up so left-to-right finger motion produces left-to-right paddle motion on the screen. Nearly everyone lines up the Trazor with the screen.

There are two sizes for the control surface that seem natural: a small size corresponding to the span of a forefinger with the heel of the hand resting on a support; and a larger, less clearly defined size for free movement of the entire hand. Preferences vary, perhaps depending on such physiological factors as small-muscle control versus large-muscle control, or such personality characteristics as expansiveness versus preciseness.

Reliability

Reliability of the controls is generally recognized as one of the key problems in present-day video games. Knobs come off, potentiometers fail, linkages bend, levers break. This problem is especially acute for arcade games, which are plagued by vandalism and violent misuse. Efforts are being made to alleviate the problem, such as incorporating clutches in potentiometers. But difficulties persist.

The Trazor completely solves the mechanical reliability problem. Not only does it have no moving parts, it has no projections at all. The control surface uses tough and durable materials developed for long-life potentiometers. The only failure modes anticipated in normal use are those of ordinary solid-state electronics.

Principle of Operation

The basic operating principle consists of establishing an electric field over the control surface whose phase varies as a function of position. When the user touches the surface, the signal at that point is capacitively coupled by his hand to an adjacent pickup surface, and the phase information is extracted from the signal. Time multiplexing utilizes the same circuitry to give outputs for both axes.

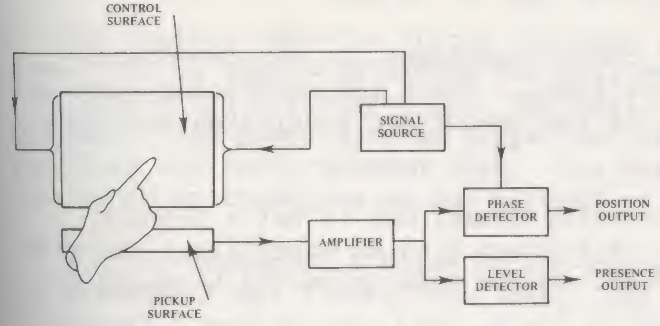


Figure 2 - Diagram of one-dimensional Trazor

Figure 2 is a diagram of a one-dimensional Trazor. A low-voltage alternating field is established along the length of the control surface whose phase, relative to one end, changes continuously as a function of distance from that end. At points in between, the signal from each end is attenuated in proportion to the distance from that end. The phase angle is determined by the vector sum of the two signals.

When the control surface is touched with a finger, a signal is coupled into the finger with a phase uniquely characteristic of the point touched. A pickup surface is located so the user's hand passes over it to touch the control surface. A portion of the signal coupled from the control surface to the finger is capacitively coupled into the pickup surface, which is connected to an amplifier. A phase detector recovers the phase information from the output of the pickup amplifier, producing an output proportional to the position of the point touched.

It is possible to provide two-axis operation by duplicating the circuitry for the second axis and operating the two sets of circuitry at different frequencies. It is simpler, however, to use the same circuitry for both axes by time multiplexing.

A level detector connected to the output of the amplifier produces a binary output signal to indicate the presence of a finger on the control surface. This circuit can be omitted if it is not needed.

Figure 3 is a cross-sectional view of the demonstration model shown in Fig. 1. Although the control surface and pickup surface were separately fabricated in this model, they can both be produced from the same material if the impedance of the pickup surface is small relative to the input impedance of the amplifier.

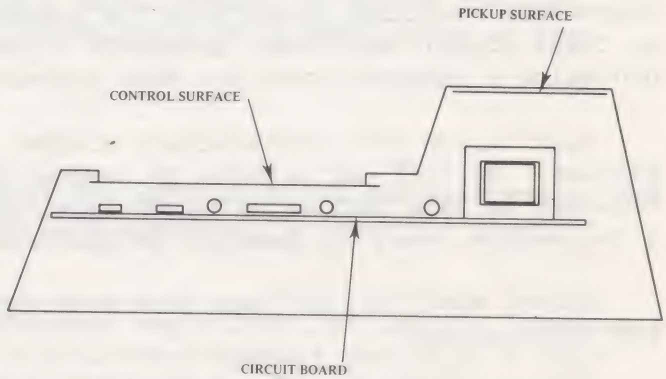


Figure 3 - Cross-sectional view of demonstration model

Origin of the Trazor

The idea of the Trazor originated while its inventor was thinking about ways to make electronic musical instruments that would be easier to play than conventional instruments but more versatile than most electronic

instruments. He quickly saw that such an instrument would need an unusually versatile keyboard, or control surface. He imagined a two-dimensional control surface that would generate tones whose pitch corresponded to finger position in one axis, and whose tone quality, or timbre, corresponded to finger position in the other axis. A second such control surface on the same instrument could be used by the other hand to control loudness and vibrato. As he thought about it, he realized that he had never heard of such a control. He began thinking how it might be implemented and soon had devised the basic scheme of the Trazor.

When video games with two-axis paddle control appeared, it was immediately obvious that the Trazor was a "natural" for games. Since the market for games was rapidly growing at that time, development of the Trazor was undertaken with this market as the target.

Peptek, Inc. is active in several innovative areas, but is not a product developer. Reston Consulting Group, Inc. is a group with an exceptional record in new product development, so the two firms decided to team up on the hardware development of the Trazor.

Development of the Trazor

In its present state of development the Trazor is a relatively simple device that is readily manufactured. The technical problems of developing it may therefore seem trivial. We found some of them far from trivial.

The knottiest problem was producing a phase field in the control surface that is linear in both axes. We immediately ran into difficulty just trying to produce an electric field that can be varied in each axis independently and is uniform at all points in the surface. We started with a square sheet of material of uniform resistivity. How do you couple signals to the square? You can place conductive electrodes along two opposite edges, apply a potential difference to them, and produce a uniform field between them with its gradient normal to the electrodes. But if you add two more electrodes and try to rotate the gradient to any other angle, a potential difference would have to be established along the first two conducting electrodes for a uniform field to exist. So you try another approach and consider combining the signals you want to apply to the two axes, using four summing amplifiers to give the four algebraic sums of the two signals. You consider applying these four resultant signals to the corners of the square. But the resistance seen by these signals will vary inversely as the square of the distance from the corners, producing a changing gradient that approaches infinity at the corners.

Fabrication of a satisfactory control surface at a reasonable cost was also a problem. We took our problem to several manufacturers of resistive materials, and together we have worked out production techniques that will bring the price down to a reasonable level in quantity production.

Patent applications have been made covering various aspects of the Trazor and its fabrication.

Game Applications of the Trazor

The Trazor can be used in a second mode of operation in addition to the obvious X and Y position control. The position of the point touched on the Trazor can be translated into polar coordinates and used to control the velocity and direction of a game feature. For most applications it is useful to set one or more thresholds,

so that operation is analogous to switch closures. A third dimension of control is provided by the Trazor's inherent ability to sense the presence or absence of the user's finger. All these modes of control can be utilized in designing new games, taking advantage of the flexibility and power provided by microprocessors. We will look at a few examples of video games that might be played with a universal control console with four Trazors spaced so they could be used by four players or by two players each controlling a Trazor with each hand.

The agility that the Trazor provides suggests adding a wrinkle to traditional games such as tennis by making the ball rebound velocity proportional to the velocity with which the player hits the ball. With four Trazors, we can also play doubles. Team games such as hockey can be played with pairs of figures passing the puck back and forth between them. One player can control a set of figures with each hand, or there can be two players on each side, making it a true team game.

A three-dimensional color Etch-a-sketch can be implemented with two Trazors. One provides X and Y axis locations. The X and Y information is translated along a diagonal Z axis by one axis of the second Trazor, simulating depth, while the second axis of the second Trazor controls the color of the display. Lines do not have to be connected, since lifting a finger will end a line and the next will begin where the player puts his finger down.

A duck-hunting game can be played in which the player must "lead" the bird. He touches a point on the Trazor and a little cloud of shot zips up from the bottom of the screen and (hopefully) intercepts the duck at that point.

Battle games of various sorts can be played using Trazors in the polar coordinate mode to control velocity and rotation of game features. A tank game for four people can be played with four Trazors, firing of the tank guns being accomplished by lifting a finger. A different tank game would use one Trazor to control the velocity and rotation of a tank hull and a second Trazor to rotate the tank gun turret.

Rectangular and polar coordinate modes of operation could be combined in a two-player game of battleship. Each player would use one Trazor to control the velocity and direction of his ship. With the other Trazor he would fire at his opponent's ship by touching the Trazor at a point calculated to intercept the ship. Three seconds after he touched the Trazor, there would be a shell-burst at the corresponding point on the screen.

Manufacture of the Trazor

Only a few Trazors have so far been built for demonstration and evaluation, but much of our effort in recent weeks has gone into lowering the cost for quantity production.

Our first models were built using operational amplifiers and similar integrated circuit modules. Since then we have made a discrete-component design as a first step in integrating the electronics. We are currently holding discussions with semiconductor manufacturers and believe the circuitry for a Trazor can be reduced to one chip and a handful of passive components, with modest power requirements. A reasonable estimate of the cost of the electronics in large quantities is between one and two dollars.

Three techniques for producing the control surface are under investigation: fusing thermoplastic resistive material into a cavity in a nonconductive plastic housing to produce a solid and continuous structure; fabricating a discrete piece of resistive plastic that will fit into a recess in the housing; and fabricating the control surface from Cermet and fitting it into a recess in the housing.

The technique of fusing thermoplastic material into a housing promises to make an almost indestructible arcade game, but at higher cost than the other approaches. Cermet, which is a ceramic substrate with metal fused into it, is extremely hard and resistant to abrasion and scratching but is omewhat brittle. It appears that the discrete piece of resistive plastic will be the least expensive of the three techniques, especially for large control surfaces. Preliminary cost estimates indicate that control surfaces can be produced by this technique for one to two dollars apiece. Even less expensive approaches are possible, such as silk screening with resistive ink.

Conclusion

We have shown that the Trazor offers two major benefits to the manufacturer of video games. It enhances the novelty and appeal of games, and it solves the problem of mechanical reliability. The Trazor also offers the manufacturer of arcade games reduced vulnerability to vandalism and misuse. The manufacturing technology is sufficiently advanced to indicate that the price will be competitive with the more complex two-axis controllers such as joysticks. Now it is up to you, the engineers and executives in the video game industry, to take the last step in the development of the Trazor from an initial concept to a commonplace household item.

VIDEO PORTRAIT SYSTEMS

GLEN R. SOUTHWORTH
Colorado Video, Inc.
Boulder CO

Computer art has intrigued many people over the last twenty years, and a few brave souls have even attempted to introduce it commercially. About 2½ years ago, a new variation was introduced which has opened up some very intriguing possibilities in the consumer market. The key factor involved is simply the processing of "real world" pictures by computer to produce intriguing images. In its simplest form, a small electronic portrait studio uses a standard television camera viewing a subject. The resulting signal is digitized and a minicomputer employed for picture processing. Typical output to hard copy is a line printer using 7x9 matrix characters and a special set of read-only memories to provide a simulation of grayscale.

The market for this basic type of system has expanded rapidly in the last two years, fueled, in part, by the large profits reported from some installations. Hardware costs can range from $7500 for a low resolution "simple minded" configuration of TV camera, digitizer, controller, and line printer, up to perhaps $50,000 or more for a moderately elaborate system with multiple capabilities.

At the retail level, the selling price of a single 12"x12" picture may range from $.90 to $5 with an average price of $3. Profitability of an installation can apparently vary widely and is influenced by factors such as basic image quality, studio location, and plain old-fashioned salesmanship. Several strategies may be used, such as selecting high traffic locations in shopping centers and amusement parks, or operating a seasonal business in resort locations. Another approach is to set up at special events such as new business openings, conventions, rock concerts, etc., in which case pictures may be sold directly or, alternately, short term rental of the equipment and operator is provided with pictures being given away for promotional purposes.

A block diagram of a typical system is shown in Figure 1 and comprises lighting, CCTV camera, video disc frame store, video digitizer, TV monitor, minicomputer, and line printer. In operation, the subject is seated before the camera and a fixed lighting pattern used. The subject is posed, "frozen", and the resulting image observed to insure that a pleasing picture has been obtained. Following this, the operator sets video levels and selects an appropriate computer program to generate a printout.

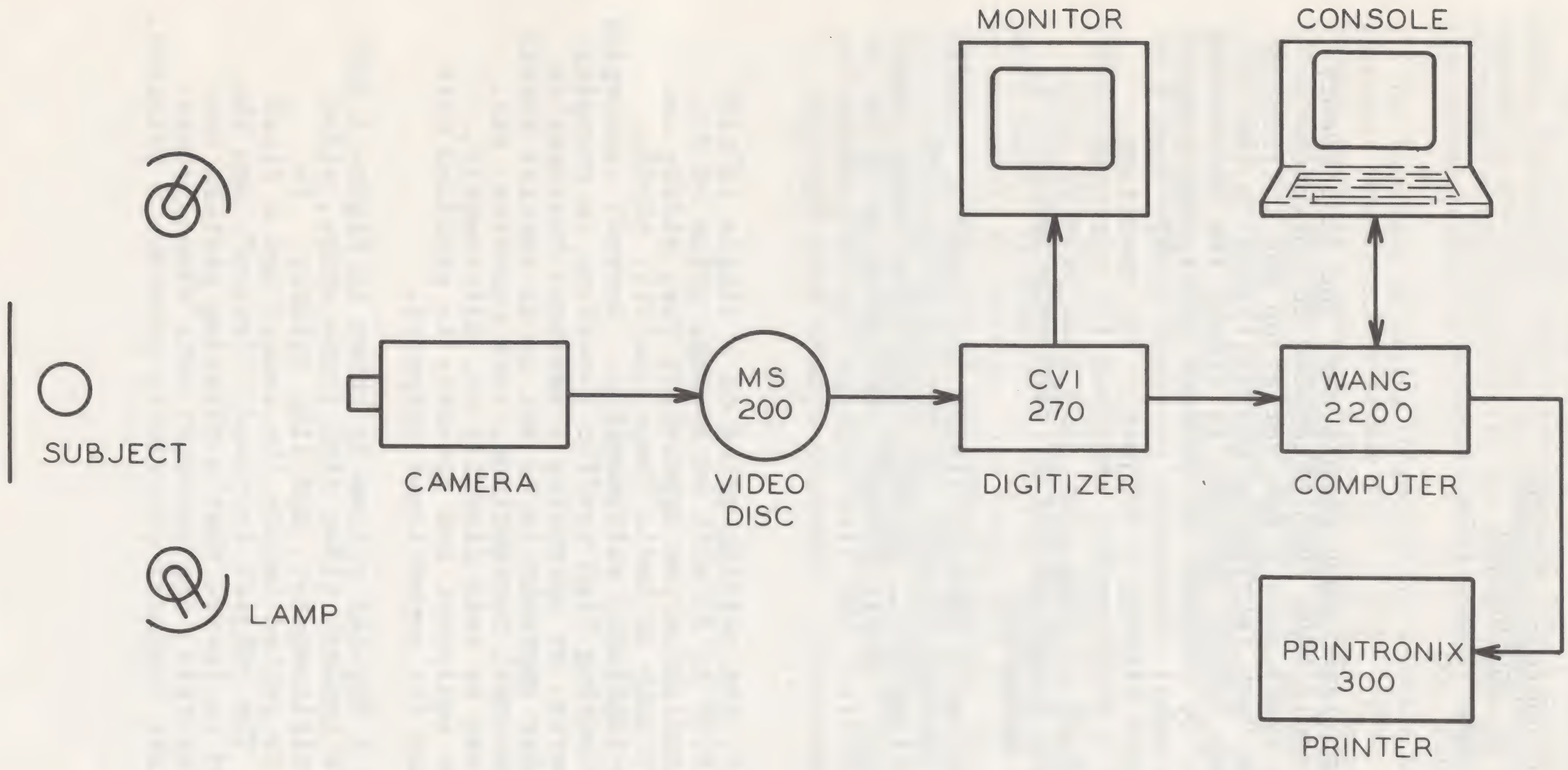


FIGURE 1
BLOCK DIAGRAM
BASIC CVI DIGITAL
PORTRAIT SYSTEM

The line printer then produces a picture, which is removed, shown to the customer, placed in a protective jacket, and the transaction concluded. An alternate procedure is to copy photographs or other art work, in which case the customer brings in original material which is placed under the camera and an appropriate printout made.

The simplest picture structure is the 12"x12" format containing perhaps 90x120 "points" of information. A typical example of one of these is shown in Figure 2 and uses a special symbol set to generate a pseudo grayscale. Figure 3 shows a different form of programming wherein a variable size dot structure is employed, resulting in the equivalent of a much enlarged newspaper "half tone". In either case the 7x9 matrix of the line printer gives a relatively coarse image and pictures must be viewed at some distance in order to produce a semblance of naturalness.

Reproduced picture quality is influenced by a series of factors, the first, of course, being reasonable flattering lighting. The TV camera is a key element as it will provide the initial limitation in picture quality. In most instances a high resolution camera will not be required and the important considerations will be freedom from noise and good grayscale reproduction. In connection with this, it is important to note that the standard vidicon camera employs an Antimony Trisulphide target which has semi-logarithmic characteristics, tending to compress the whiter portions of the picture. This is desirable when looking at a television monitor as it compensates for the anti-log characteristics of the CRT, but can have some negative aspects when a limited number of grayscale levels are digitized and when hard copy is generated. Camera tubes with linear characteristics are readily available, with the most common being the silicon diode target tube. This tube also has the advantages of exceptional ruggedness and freedom from accidental damage due to exposure to bright light. Estimated lifetime is approximately 10 times that of a conventional vidicon tube.

Inasmuch as the total "printing" process may take from 30 seconds to over a minute, it is highly desirable to have some means of picture storage so that the subject will not have to remain in a rigid pose for the entire process. Typical memories can include scan conversion tubes, video disc recorders, a digital field freeze, or the minicomputer memory itself, when used in a fast DMA mode. Using a memory prior to computer processing is convenient in that it allows the operator to preview the basic image and insure that a pleasing result has been obtained. This can save a considerable amount of paper and/or customer dissatisfaction.

Figure 2

Figure 3

Several approaches to digital conversion of the video signal may be made. First, a very high speed A/D may be employed doing a line by line conversion and dumping into a digital memory. Such A/Ds are not too expensive when operating in a reduced resolution, reduced grayscale, format such as 128x128x4 and, in fact, you can get a complete package including a buffer memory in the Robot Research Model 400 Ham Slow Scan TV Converter. A note of caution, however, 4 bits of grayscale, or 16 levels, will normally not give completely satisfactory quality due to a phenomenon known as "contouring" which gives a distinctly artificial appearance to the reproduced image and frequently causes a loss of important detail. A 5 bit system is preferable for naturalness.

A second form of A/D conversion uses relatively slow speed sampling, essentially taking one sample per TV line which allows approximately 60 microseconds to make an A/D conversion. This is a very effective and economical approach to achieve both high resolution and extended grayscale.

With an actual minicomputer based system, a wide range of programming variations may be used to alter the end picture product. For example, pictures may be individually titled and dated, with perhaps a few pertinent comments added. One system uses a computer generated border, and other variations include multiple images, strip pictures, giant pictures (made by gluing two or more strips together), and deliberate tone reduction or "posterization" which reproduces an image having from two to four shades of gray.

Most systems in the field appear to employ conventional line printers such as manufactured by Centronics and Printronix, frequently with slight modifications to achieve closer character spacing. A variety of papers and ribbons are available for use with this type of printer, including sublimating inks for heat transfer processing. More expensive units such as the electrostatic printer-plotters can produce appreciably higher resolution images for a given paper area. It is also feasible to use direct CRT/hard copy output devices but, unfortunately, the dry silver paper used in this process has some disadvantages, namely limited size, high expense, and a fugitive image quality when exposed to intense illumination such as direct sunlight.

As in any computer based system, a large number of variations may be anticipated. These include not only ingenious programs but the use of accessories such as floppy disc memories for reference picture storage or customer reorders. Two or more TV cameras may be used with combined signals and special effects equipment to expand graphic input capabilities. For the serious operator, picture output may be produced photographically in

Figure 4

terms of slides or prints, allowing the use of full color for a wide range of effects.

In conclusion it should be noted that the video portrait field is very much in its infancy and system installations, for the most part, are producing relatively crude and unsophisticated pictures for the walk-in consumer trade. It is, however, a <u>personalized</u> and distinctive product.

In the near future we may expect very substantial improvements in quality and techniques and an increase in professional and semi-professional services. Perhaps the 1890s photo studio, currently undergoing a surge of popularity, will face stiff competition from the computerized system which provides an endless number of variations in imagery.

#####

X

TV GAME DESIGN: PARAMETERS, PITFALLS, POTENTIALS

Stephen Beck
Video Design Consultant
1406 Euclid
Berkeley, CA 94708

Introduction. The advent of television was seen as "radio with pictures" in the '20's. Later, the implementation of television broadcasting restrained the individual to being a passive viewer of programs. One could watch a game but not play it. During the late '60's, diverse groups of television engineers and artists were quietly expanding television into an active participation tool based on the concept of video synthesis.

We are not in the midst of a "video revolution" which ushers in the era when a person can control the television picture rather than just watch it - surely the most profound change in the nature of television since the inception of broadcasting itself.

While acknowledging the significance of the home video game and the marketability of diverse products for it, the main purpose of this presentation is threefold: 1) Review the basic elements of TV display parameters and develop an informational approach to them; 2) Describe a few of the subtler areas encountered in video design such as spurious edge effects, chrominance-luminance resolution limits, and horizontal control jitter; 3) Present aspects of new game design and the role of the game design consultant. Also, to present videotape samples of an electronic artform which may emerge as TV games evolve into more creative devices.

The ultimate saleability of the TV game is a balance of many factors. Features such as many colors, elaborate sounds, and multi-controllers weigh against manufacturing complexity, texting, and new game turn-around time. One might expect the immediate polarization of the market into low cost limited action types and top end programmable game systems, the latter opening up non-game areas of practical and creative significance.

In any event, the public is difficult to second guess, and the "hit games" of tomorrow will surprise everyone here today.

Video Display Parameters: Designers and programmers of TV games must convert pictorial concepts into moving patterns of colored dots on a TV screen. This process is much akin to motion picture animation and requires a good feel for how a TV picture is actually generated.

The definition and resolution of video "objects" synthesized for game use is limited by the bandwidth and speed of the circuit technology employed. On the receiver end most home TV sets of high quality have a video bandwidth of 4.2 MHz though the average set is more likely to display an effective BW of much less. The perfectly adjusted set will deliver about 340 usable dots per line, but there are qualifications.

The TV picture can be thought of as a rectangular matrix of elements. There are 525 horizontal rows in the NTSC system, each row containing N picture elements called pixels. N can be thought of as a resolution variable set by the speed of the generating system. The complete array forms 1 TV frame, itself defined by 2 fields (shown as dot and dash in the diagram below). Motion is achieved by presenting 30 frames per second, such that persistence of vision comes into play.

```
                          (263,M)- - - -(263,N)
   (1,1) . . . . . . . . . . . . . . . .(  1,N)
 (264,1) - - - - - - - - - - - - - - - -(264,N)
   (2,1) . . . . . . . . . . . . . . . .(  2,N)
 (265,1) - - - - - - - - - - - - - - - -(265,N)
   (3,1) . . . . . . . . . . . . . . . .(  3,N)
                         .
                         .
 (261,1) . . . . . . . . . . . . . . . .(261,N)
 (524,1) - - - - - - - - - - - - - - - -(524,N)
 (262,1) . . . . . . . . . . . . . . . .(262,N)
 (525,1) - - - - - - - - - - - - - - - -(525,N)
 (263,1) . . . . . (263,M-1)
```

Matrix model of video raster.
(Interlaced scan)

Lines are numbered in actual scan order. Each field represents every other actual scan line, with alternate sets of lines interlacing together to form a smooth blend of lines and reduce flicker, since the field rate is twice the frame rate - you see twice as many "half picture" per time interval.

Notice the ½ line length at top and bottom of frame, which is the interlace match point. Since 525/2 = 262½ each field will have 262½ lines. Some 20 of these lines are actually blanked and do not figure into the picture display time, which will be a maximum of 241 per field.

The video generator must also supply a sync signal to form the basic raster. Sync consists of horizontal pulses, equalization pulses, and serrated vertical pulses. The vertical sync interval is shown in figure 1-A for both fields of an interlaced system. Notice the H/2 period during vertical timing, which is the result of interlace. This maintains H sync during the vertical sync period which is 3H in duration.

TV sets perform sync separation by differentiating to extract horizontal sync and integrating to get vertical sync. It can be shown that H sync tolerance is about 1 part in 600 while V tolerance is even tighter at 1 part in 5000. Loss of interlace will occur with as much as 3 μsec vertical timing error. Thus equalization pulses must be used to prevent premature firing of vertical sync. Figure 1-B illustrates.

The last H sync of the top field is a T1, while T2 on the next field it is displaced ½H respect to vertical sync, T4. If T3 were chosen as the start of vertical sync a voltage difference remains on the integrating capacitor V3 of 2:1. By waiting 3H the voltage ratio difference at T4 is 4H/3.5H = 1.14:1. The width of the equalizing pulse must be 1/2 that of the horizontal pulse to maintain average sync voltage. While the charge is not totally equalized it is substantially more stable.

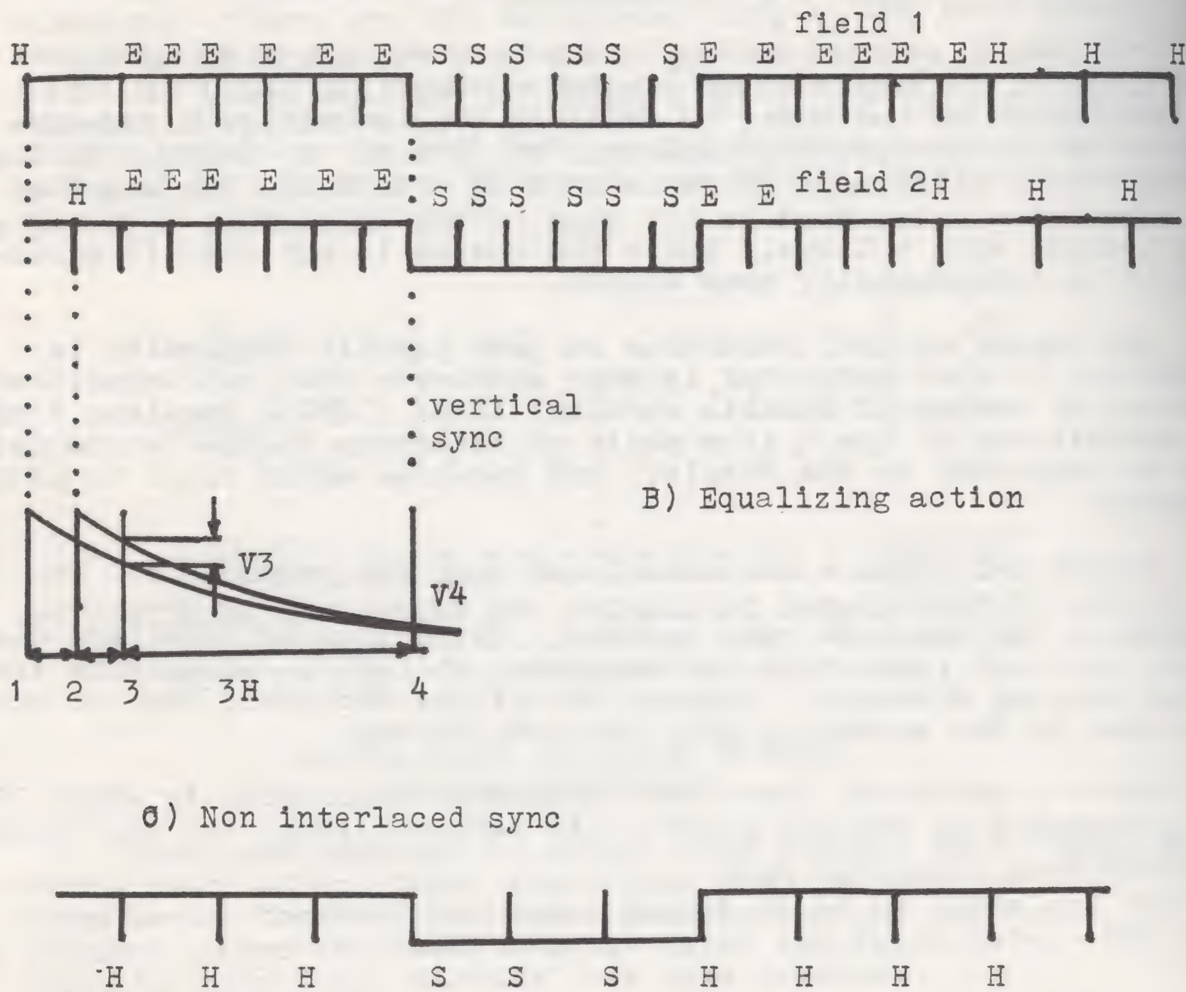
The impact of full interlace on game circuit complexity is threefold: 1) sync generator is more elaborate than non-interlaced version; 2) number of usuable vertical lines (480) requires 9 bits for definition; 3) the ½ line shift on alternate fields introduces a 30 Hz component to the display, and requires extra logic to adjust counters.

Figure 1-C shows a non-interlaced sync for comparison. The generation of this signal is simpler and represents an effective compromise for low cost sync systems. While loss of interlace does impair vertical resolution the resultant picture is acceptable from normal playing distance. Indeed, the player shouldn't have to stand too close to the screen to play the game anyway.

Since a practical limit for horizontal resolution is about 320 lines it is possible to use 3/4 x 320 = 240 vertical lines for equivalent resolution.

FIGURE 1: TV Vertical Sync Interval

A) Interlaced sync



Resolution: Video is a bandwidth limited system. The relationship between risetime RT and bandwidth BW can be expressed as:

$$(BW)\ (RT) = k$$

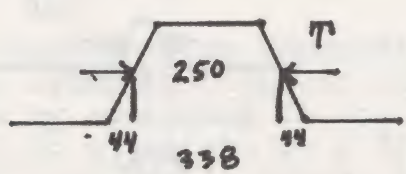
where BW is the -3 db point in Mhz and RT in microseconds 10%-90%. A typical value for k is o.35 which gives the following values:

BW Mhz	RT nsec
1	350
2	175
3	117
4	88

Figure 2a shows a maximum resolution pattern of 48 adjacent pixels, alternating black to white. One pair of pixels produces one complete H cycle of video. The 4/3 aspect ratio requires that there be 8 pixels wide for 6 pixels high. In the maximum interlace mode the 480 scan lines imply 640 horizontal pixels, or 320 TV H cycles of video, during the active line time.

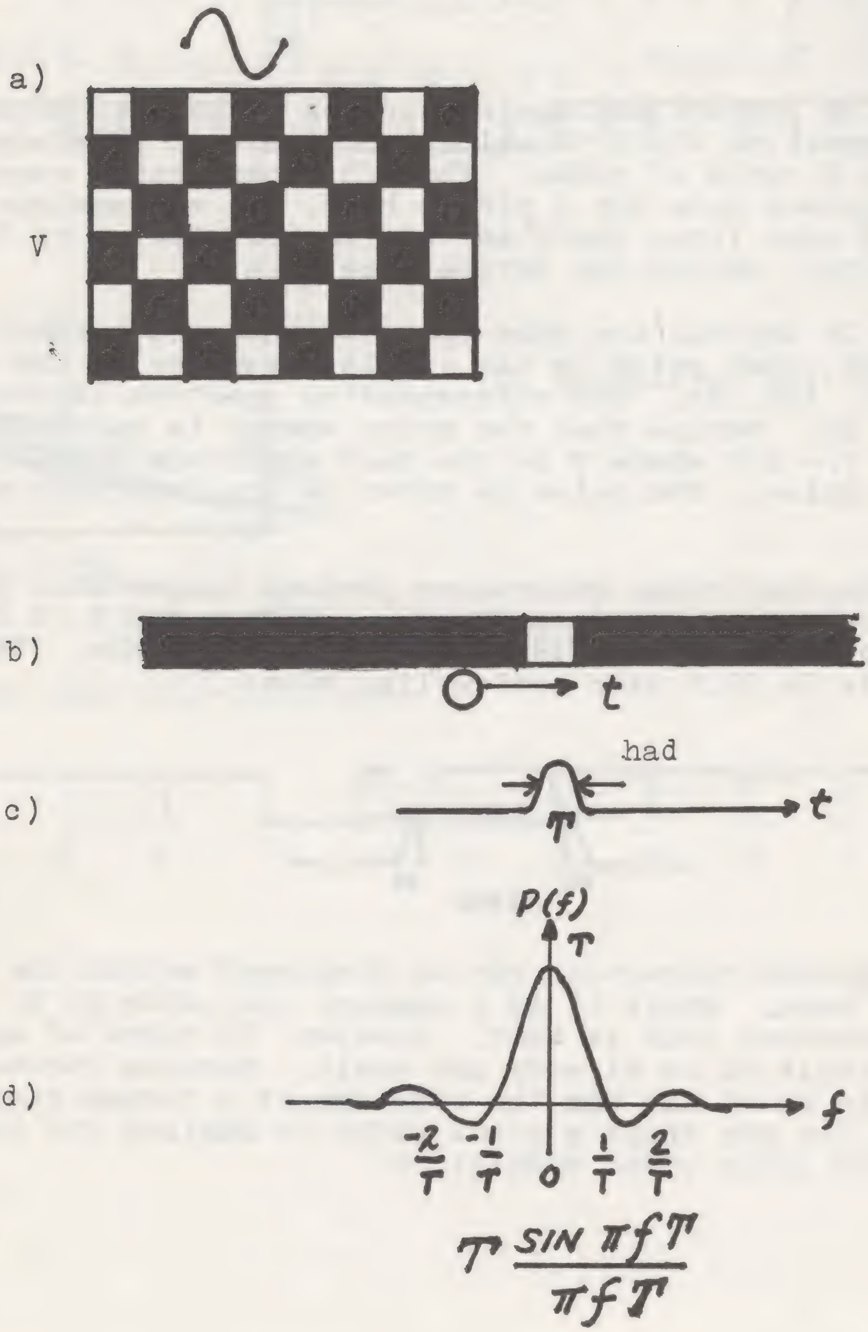
Figure 2b depicts the scan spot encountering 1 ideal pixel. The resultant video pulse is the impulse response of the low pass filter, h(t), fig. 2c. The corresponding spectrum of this pulse is shown in 2d. Notice that the major energy is concentrated between 0 and +/- 1/T where T is the half amplitude duration (had) of the h(t) pulse. The pulse is known as the (sin T)/T or sine^2 impulse.

Since digital video generators produce trapezoidal pulses risetime should be limited to 88 nsec. With a had T of 250 nsec the total pulse rate is 1/338 nsec or about 2.95 Mhz. This results in 155 pixels in 52.5 usec active line time:



About 26-5x7 characters can be displayed across the screen at this bit rate. While it is a seeming low value it is compatible with MOS processes such as NMOS. However, in terms of applying chroma to pixels it is already too small. Because chroma bandwidth is limited to about 1.6 MHz the risetime of a chroma pixel is 220 nsec. Thus not too short a pixel width is desired for true bandwidth limited color video modulation.

FIGURE 2: Resolution



<u>Picket fence edge effect</u>: One spurious effect which can creep into video game displays results from using the chroma subcarrier as a video clock. Since the defined relationship between Fsc and line frequency Fh is

$$Fh = 2/445\ Fsc$$

and there are 262.5 horizontal lines per TV field, the number of cycles of subcarrier per field can be determined:

$$\#\ \text{SC cycles per field} = 445/2 \times 262.5 = 58{,}406.25$$

The ratio chosen results in a subcarrier phase pattern of 4 TV fields (2 TV frames) period. That is, for a given subcarrier phase at some line beginning 2 frames must elapse before this phase repeats itself.

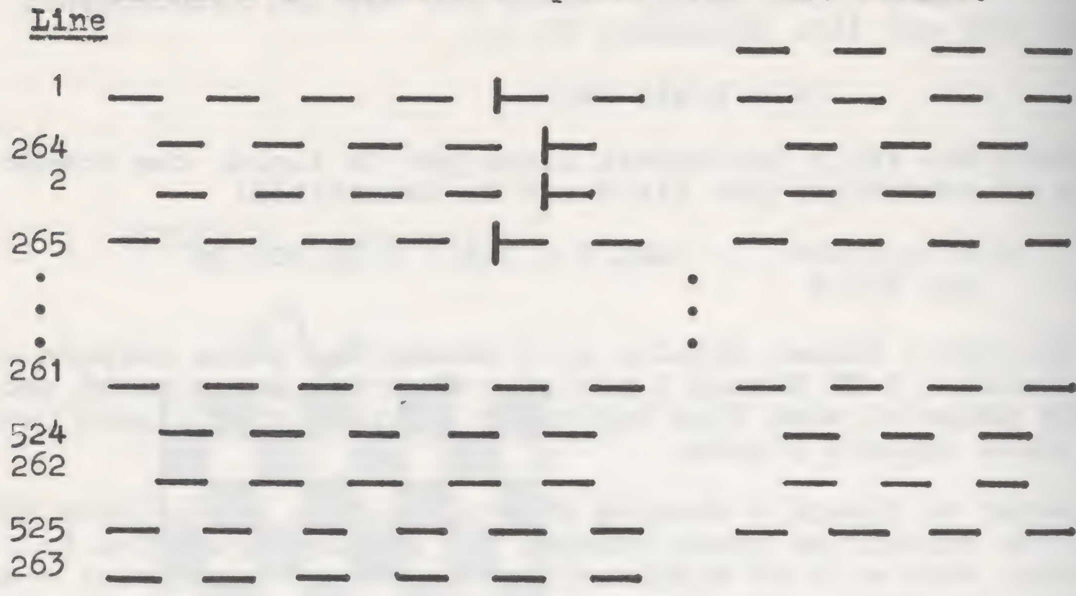
Refer to figure 3 showing this pattern in abbreviated form. Since the subcarrier phase changes 180 degrees from line to line any given edge will be displaced by ½ cycle of subcarrier time, about 140 nsec for NTSC. The lines are numbered in sequential order as they actually occur in time for an interlaced system.

With the convention of the figure a true vertical edge of a given location is shown for the 5th 0--1 edge on the first 4 scan lines. Notice the alternating displacement both from the line-to-line basis and the frame-to-frame basis. The latter will induce a slight 30 Hz flicker component to the edge.

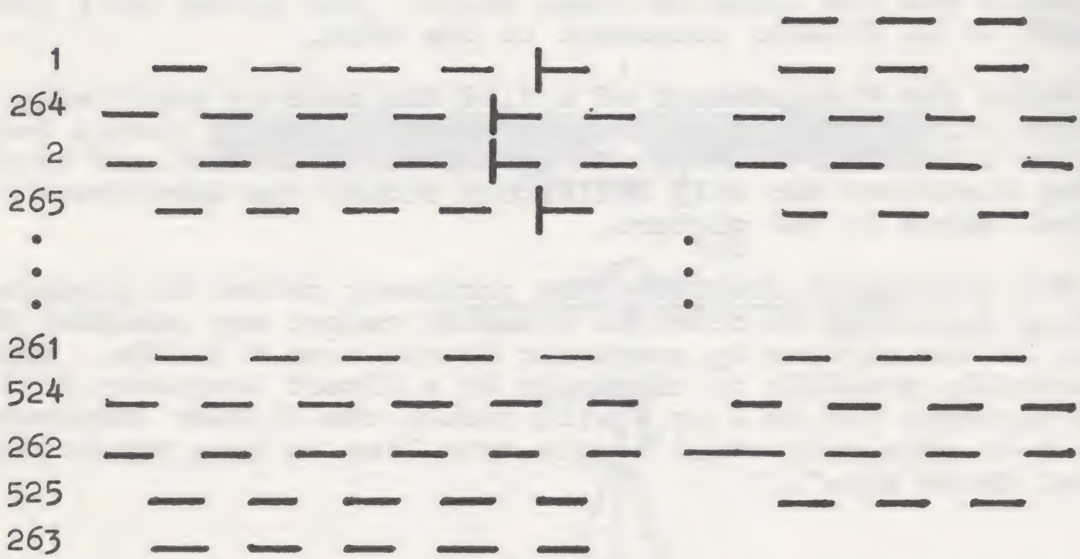
While the displacement of a 3.58 Mhz rate is admittedly small, the edge effect can ripple down to lower frequency clocks derived from the subcarrier itself. Its presence is not noticed from typical playing distances but will definitely reduce the smoothness of vertical edges in the picture.

The subcarrier frequency was purposely chosen to produce the shifting described in order to visually cancel any residual 3.58 component in the picture by averaging it out over 4 fields. Thus,it is not actually possible to eliminate by a direct frequency divider. While dividing Fsc by 2 or 4 will reduce the flicker component a given 0--1 edge will still toggle from line to line producing the "picket fence edge".

FIGURE 3 : Subcarrier phase over 2 TV frames.



Frame 1



Frame 2

Chrominance-luminance resolution. In designing TV games for standard television receivers one should be aware of the signal processing encountered and the corresponding limitations this places on color resolution. Color in a TV display is produced with 3 primary colors, red, green, and blue. So that color and monochrome TV can be compatible a defining relation between the luminance or brightness of each spot in the scene exists:

$$Y = .30\,R + .59\,G + .11B$$

Y is the "black & white" portion of the signal while C (for chrominance) contains information about hue and saturation of the color in the form of a phase and amplitude modulated subcarrier at 3.58 MHz. Figure 4a shows this chroma vector.

The 2 axis of the vector plane are called (R - Y) and (B - Y). With Y given these 2 vectors can be used to algebraicly solve for the third color green. A reference at 180 degrees (called burst) defines the phase for synchronous demodulation in the TV set of the 3.58 MHz signal.

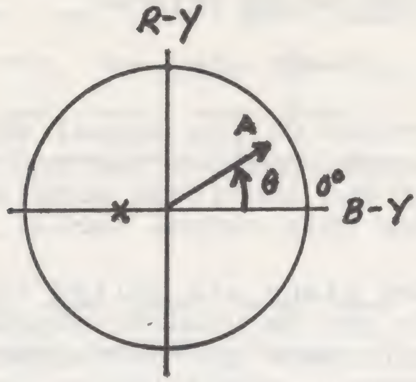
Figure 4b shows a close-up of about 75 kHz of video frequency spectrum. The energy lobes of Y and C are shown. Since each sample of a TV line is scanned at 14 kHz rates the sidebands extend upward in frequency at integer multiples of Fh, the horizontal scan frequency.

In order to minimize interference between chroma information the subcarrier is chosen to be an odd half multiple of the line frequency, causing its sidebands to lie interleaved at integer half multiples of the line frequency. In order to properly separate the two signal components a true comb filter approach must be used; however, virtually no home TV set employs this technique. The result is a less than perfect separation of color and monchrome information from the composite video signal, and a limiting resolution on the color information.

Figure 4d shows a typical TV receiver technique for separating Y and C. Basically, a bandpass filter formed of a resonant parallel tank circuit centered at 3.58 Mhz steers the dominant chroma sidebands to the chroma demodulators to produce R-Y and B-Y signals. The Y signal proceeds through a delay line to compensate for timing shifts through the bandpass. It may also be notch filtered to remove or reduce 3.58 Mhz components..

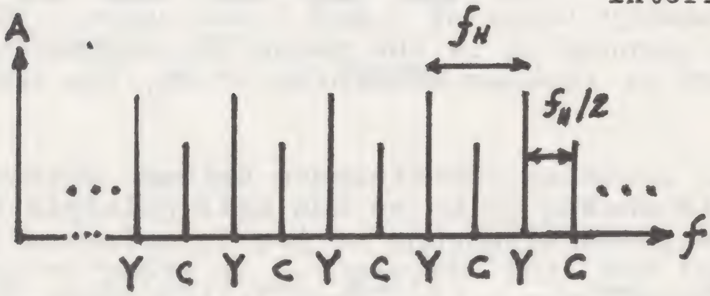
Unfortunately, the video spectrum extends only about 0.6 Mhz above the chroma frequency so the bandwidth filter must cut off at 4.2 Mhz, severely limiting the actual color resolution. Any attempts to pass fast chroma pulses through the circuit will meet with varying results as the damping of the tank resonance varies from set to set.

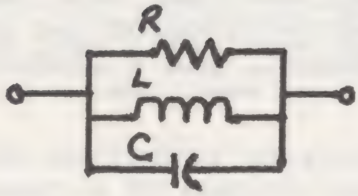
FIGURE 4 Aspects of TV Color



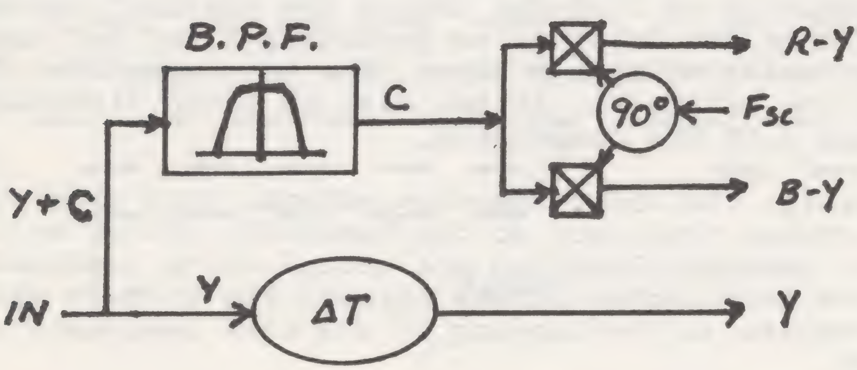
a) chroma vector

b) frequency interleaving





c) resonant tank



d) typical TV receiver chroma separation

Figure 5 shows the basic responses to a step function (a) for an overdamped (b), critically damped (c), and underdamped (d) system. In any given TV set one might expect any one of these states to occur, depending on the Q of the bandpass, peaking effects, and saturation of color.

Figure 5e depicts a brief video pulse and the possible responses of the chroma section to it in (f). Responses 1 and 2 will show very little saturation as well as color smearing, while response 3 will exhibit more saturation but with a reduced color "echo" on the right side of a vertical edge, with possible cancellation of the chroma entirely.

The minimum duration of a chroma pulse through a 0.6 Mhz filter would be about 1.66 microseconds, allowing a true color resolution of only about 50 pixels per line. The TV game designer working for a home TV should realize that overall color detail will not be very good, and that most of the fine detail must be carried by the Y channel.

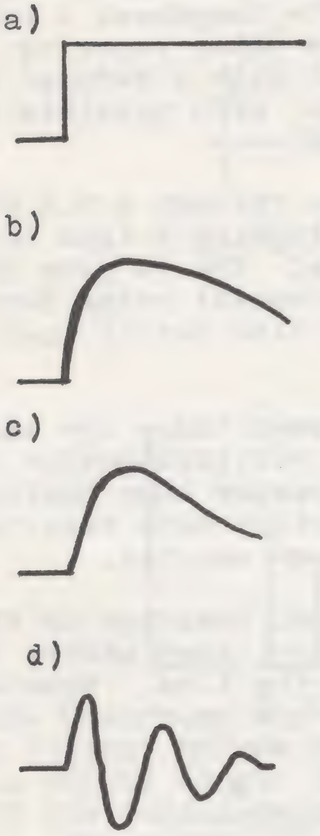
Horizontal control jitter. Most TV games today use analog potentiometers as controllers, with mainly vertical motion only. Since the vertical resolution is so much greater than horizontal attempts to use pots to control sideways motion have resulted in "jittery" control which is difficult to place exactly.

As can be seen in Figure 6, a given spot location on the CRT raster is continuously defined to within 1 spot width, and an edge can start more or less anywhere on the line. However, in digital displays, the horizontal positions are quantized and restricted to discrete locations, as in (c). Thus, an analog control with continuous function to define location will try to locate an edge at a non-existent position (d). The resultant action can be an annoying jump of the paddle from one adjacent cell to the next.

The obvious solution to the problem is to add hysteresis in either hardware or software form. Until horizontal resolution increase to the point of vertical this jitter will be primarily a horizontal phenomena. Some approaches to digital controls solve the problem at the expense of "direct" player control of the location, but this can adversely affect playing action in the game.

Let it be noted that continuous function controls (i.e. pots) versus "up/down" or "left/right" button types require substantially different player skills, a fact which can augment or defeat a given game concept.

FIGURE 5 Impulse responses to video pulses



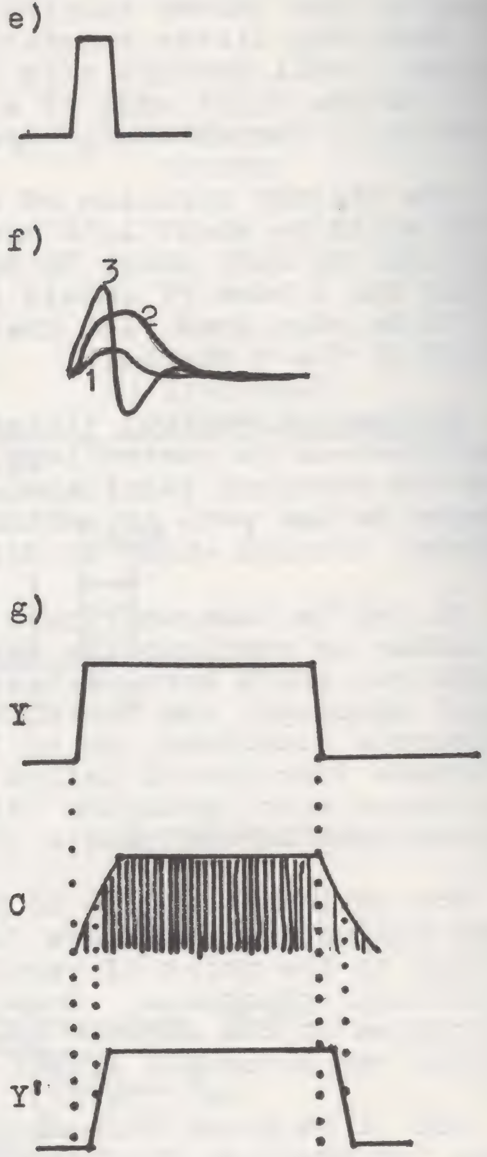
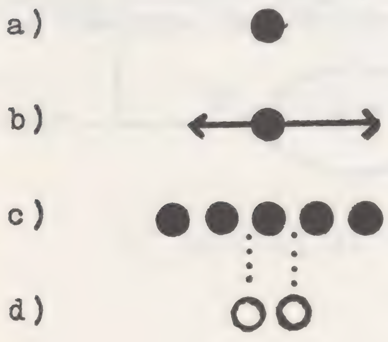


FIGURE 6 Horizontal stability



Potentials. As TV games become more sophisticated and computer type systems come of age, a natural source of game concepts will likely be the library of "computer" games in existence. While appealing to many because of intellectual or mathematical style, the bulk of these games will require reprogramming for TV type display rather than printers or terminal outputs currently used by computers. Also, it is important to realize that TV is an action medium of color and sound, almost exactly opposite of a computer terminal.

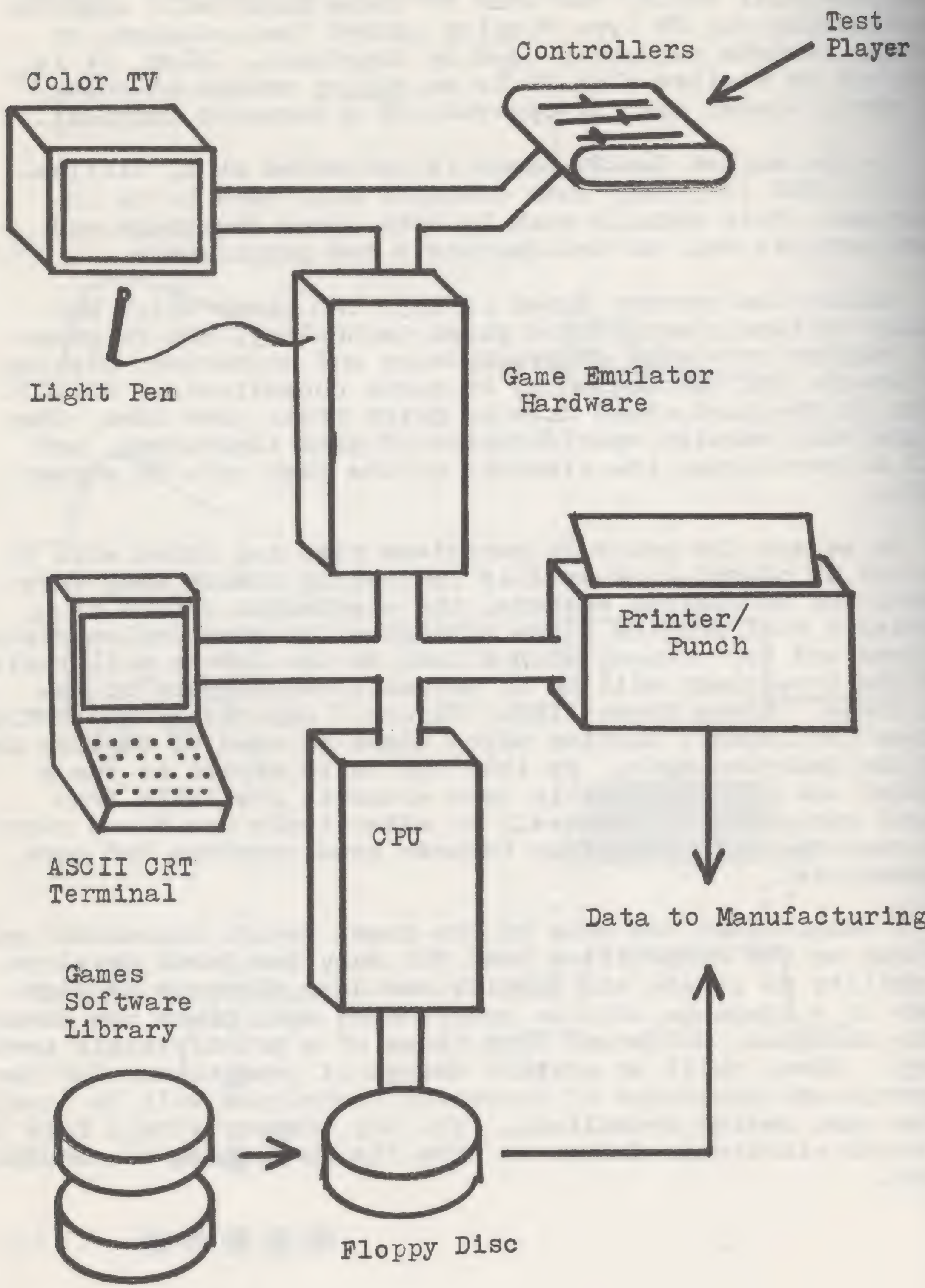
As the market for TV games is projected at 21 million units by 1980 (4), many game concepts will have to be implemented. This entails work by both games designers and consultants as well as manufacturers and programmers.

Unlike the current lines of toys and games which basically utilize plastics and print technology, the TV games will require knowledge of programming and animation, placing new demands for conceptioning on games consultants. While a person in the past could draw or print their game idea, the TV game will require specification of game algorithms and skill at portraying the elements of the game on a TV screen matrix.

As we see the price of petroleum rise and along with it the cost of plastic, as well as increasing trends away from plastic for ecological reasons, the electronic canvas of television will provide a new substance for game implementation. The game and toy company with a look to the future will realize that the investment will be in software development of new game ideas. Along these lines, Figure 7 depicts a hypothetical TV game development station which might be used to develop and test new game concepts. By 1980 one could expect to see a standard set of programmable game elements available from several semiconductor houses. To effectively use these parts will require solid interface between game creators and game implementors.

I submit that the role of the games design consultant will increase as the competitive need for many new games develops. The ability to create and specify new game elements as algorithms in a language akin to programming will place new demands on the designer, different from those of a print/plastic technology. Also, skill at graphic design of game tokens for the TV matrix and knowledge of animation techniques will be invaluable to the game design consultant. The toy company should know how different electronic design is from its past forms of manufacturing.

FIGURE 7 TV Game Development Station Proposed



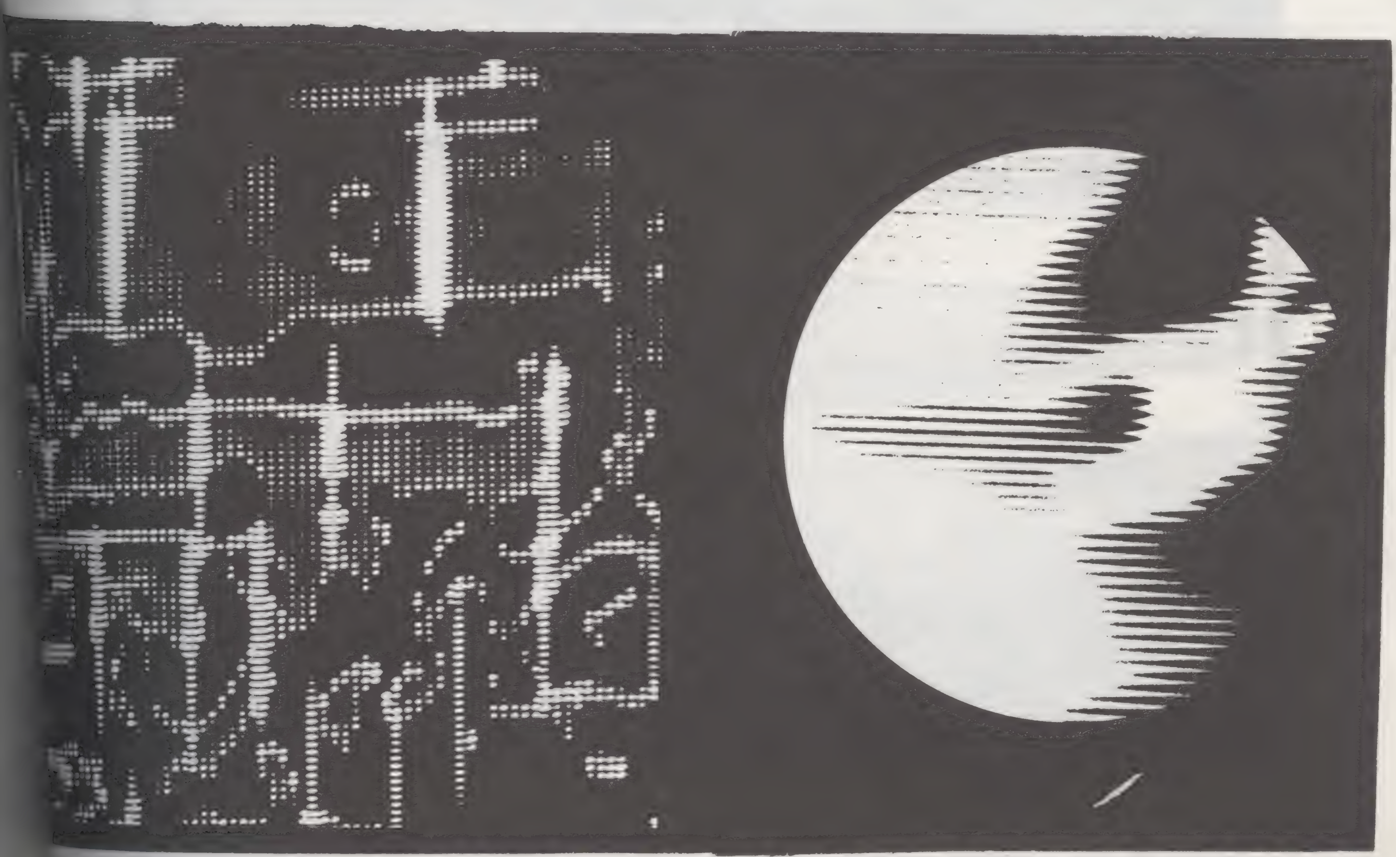
<u>Electronic Video Art</u>. On a final note I would like to present some basic ideas toward the area of electronic art as a direction that video games will take. In terms of a strict definition the ability to create a television picture out of basic elements is what I mean by video art.

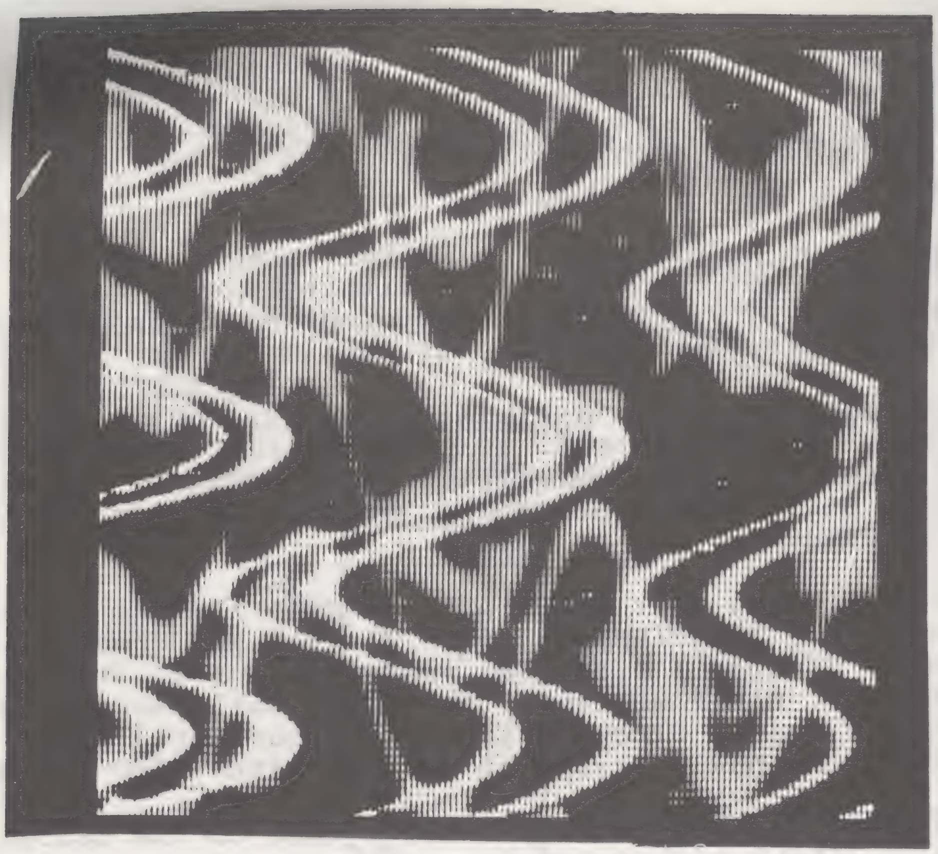
The results of my own research in this area has led me to fashion a basic set of visual ingredients consisting of color, form, texture, and motion. By permuting these elements in various ways a large number of distinct images can be formed.

The divergence of video art will encompass both realistic and representative forms as well as more abstract and decorative styles. As one set of examples of what might be done in this area some still frames are shown, photographed in black and white, in Figure 8.

As the completing part of my presentation I shall present a videotape called "Illuminated Music" which I performed with my Direct Video Synthesizer several years ago, on a live broadcast over KQED-TV, San Francisco. In it you will see some 30 or more distinct image effects which I have perfected and simplified over the past 8 years of working with video synthesizers.

As to what lies beyond this, I leave that to the designers, engineers, and others in attendance at "Gametronics", 1977.





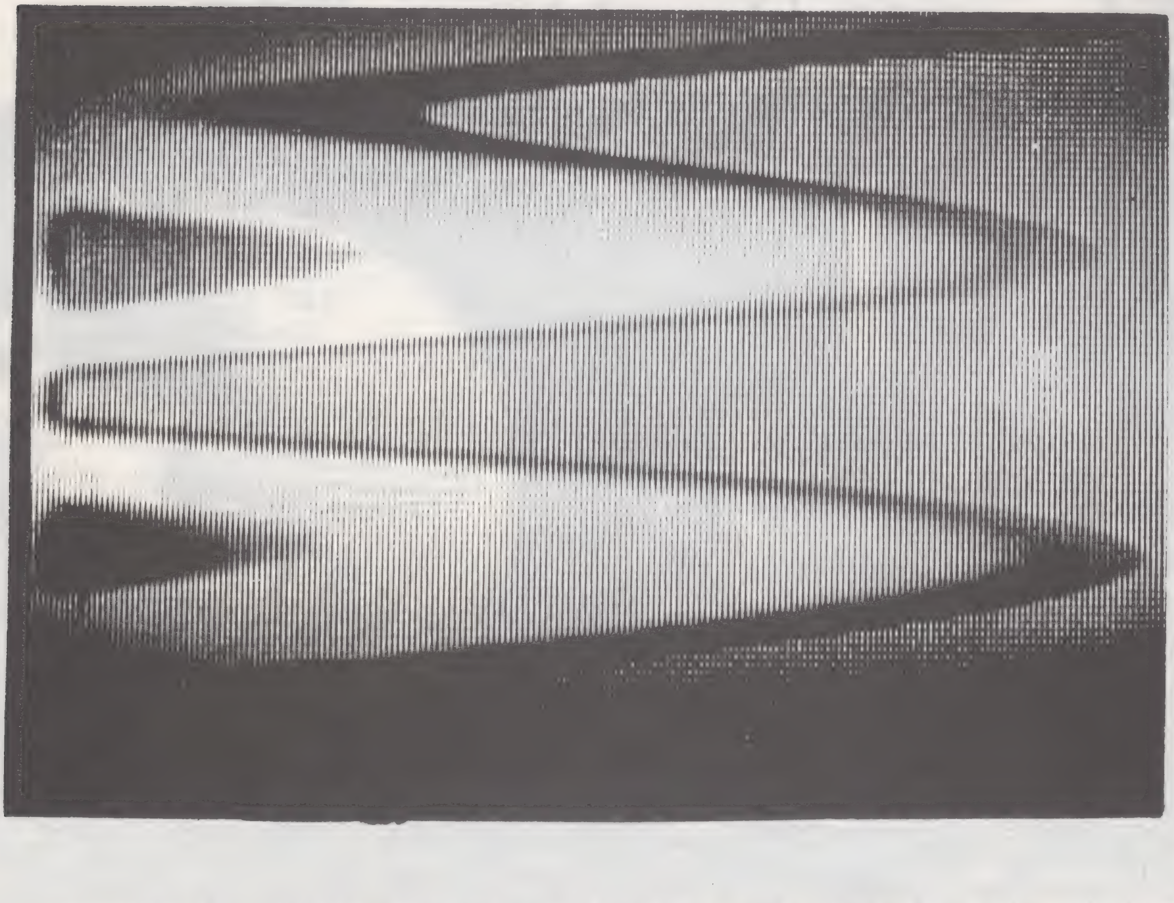


FIGURE 8: Still frames of abstract electronic art. Actual color from TV screen not shown.

References.

1) "Image Processing and Video Synthesis", S. C. Beck in Video Art, 1976 Harcourt, Brace, Jovanovich.

2) TV Systems Maintenance, p. 51, 1st edition; Harold E. Ennes, 1968 Howard W. Sams.

3) "Problems of Splicing and Editing Color Video Tape" by Charles Anderson, Ampex VTR Training Manual, 1969.

4) "Games" from February, 1976 Report by DATAQUEST.

Additional Sources.

1. TV Video and Sound Circuits; TV Sync and Deflection Circuits, by Thomas M. Adams, 1968 Howard Sams Inc.

2. Performance Guidelines for Video Players FROM Consumer Products Engineering Bulletin No. 5, 1973. E. I.A. Engineering Dept., Washington D.C.

3. "Direct Video: An Electronic Artform for Color TV" by S. C. Beck, 1972 Proceedings of Society for Information Display Conference, 1972.

4. Introduction to Solid State Television Systems Gerald L. Hansen, 1969, Prentice-Hall, Inc.

5. "PCM NTSC Television Characteristics" A. Goldberg, Journal, SMPTE, Vol, 85 No. 3, March, 1976.

6. "Measuring Distortions in the Television Signal" Charles W. Rhodes, Tektronic 1973.

Author Background.

Stephen Beck is the inventor of the Beck Direct Video Synthesizer and well-known experimental video maker. His videotapes are in private and public collections internationally. He holds a BSEE from University of California, Berkeley, and has also worked at Public Televisions Experimental Center. He also has worked in electronic music and currently is a TV Game design consultant to National Semiconductor Corp., Santa Clara.

Beck is a member of SMPTE, Eta Kappa Nu, and Phi Beta Kappa, and operates a private video studio/lab in Berkeley, Ca. at the current time.

XI

TV GAMES AND THE FCC

DANIEL J. NORTON
Sanders Associates, Inc.
Nashua, New Hampshire

There is a real need in the TV/Video Games Industry for a better understanding of how it should relate to the FCC. There seems to be a growing feeling throughout the Industry that casts the FCC in the role of an antagonist. Within a particular company, that feeling intensifies whenever their effort to obtain the FCC's Type Approval of their product fails, and production is stalled. On the other hand, the FCC is operating under a set of Rules and Regulations which are, in some instances, rooted in antiquity or built on obsolete technical foundations. Neither side views this situation as desirable, but at least one side can move to improve it: The TV/Video Games Industry!

There are two sections in Part 15 of the FCC Rules and Regulations which pertain to TV games: Paragraph 15.7 covers those games which do not utilize the RF front-end of a television receiver, but rather feed the basic sync and video signals directly to deflection and video amplifiers. These types of games will be referred to in this paper as "video games." Paragraphs 15.401 through 15.423 (also referred to as "Subpart H") pertain to those games (which we will refer to as "TV games") that generate a modulated RF carrier on one of the VHF TV channels. This RF carrier is then fed into the front end of a standard TV receiver. The distinction between these two types of games is important from the FCC's standpoint for two reasons: First, the technical Regulations are somewhat different. Second, the FCC has no record of any actual interference problems occurring from the use of TV games, but they do have records of interference conditions, some of them potentially serious, which have been caused by video games. (This has been a factor in the generation, by the FCC, of a "Notice Of Proposed Rulemaking", NRPM, which changes the video game radiation and test procedures, and adds a requirement to test the levels of electromagnetic energy on the ac powerlines. See FCC Docket No. 20780.)

The question the TV Games Industry should be asking at this point is, "Are these two areas of Regulation reasonable?" Unfortunately, neither we nor the FCC really know. The Industry has a great deal at stake here. Are we being burdened by unnecessarily severe electromagnetic emission restrictions? On the other hand, if the requirements are not strict enough, the Industry stands a good chance of acquiring a bad name as the result of numerous electromagnetic interference (EMI) problems. We could even be the victim of congressional over-reaction if the problem became severe enough.

The Computer and Business Equipment Manufacturers Association (CBEMA) recognized this potential problem some time ago. They took positive steps to forestall the imposition of unrealistically stringent Part 15 requirements on such things as computers and business office equipment by the establishment of a subcommittee to study potential

---

Stephen Beck, game consultant.

EMI problems, measurement techniques, and reasonable limits. A report[1] was then issued by the subcommittee, primarily for the purpose of presenting recommendations to the FCC as to what, in their view, constituted a reasonable set of requirements. It is most important to observe that their recommendations were backed up by extensive research and a resulting rationale which was extremely thorough. That the FCC really does listen to and consider such inputs is evident from the following quotation from their NPRM, Docket No. 20780. In the section dealing with proposed changes to Paragraph 15.7, which governs video games, the FCC states that:

> "....there is reason to believe that the proposed technical requirements may still be too stringent for many commercially operated computers and Data Processing Equipment (DPE). This is based on several considerations. One is an interim report released by the Computer and Business Equipment Manufacturers Association (CBEMA) on 'Narrowband RF Emanations from Electronic Data Processing Equipment and Office Machines'.... For these reasons, the Commission is willing to entertain an alternative proposal .... if sufficient justification is provided. Information dealing with all aspects of the operation and interference potential of this equipment is solicited. In particular, information with respect to the following questions is sought:
>
> (1) What levels of emissions from computers exist today?
>
> (2) If the proposed limits are not acceptable .... what would be reasonable alternative limits?
>
> (3) What equipment should be subject to these limits? ....
>
> (4) How would the limit be applied to a system comprising a number of units interconnected by cables, etc.?
>
> (5) How would measurements be made to determine compliance with the limits? ....
>
> (6) What restriction should the Commission place on the manufacturer as a precondition for marketing to ensure compliance?"

The CBEMA Report recommends limits for electromagnetic radiation and powerline emissions which are somewhat more lenient than those the FCC is proposing. A final decision (i.e., issuance of a "Report And Order Amending The Rules") is yet to be made by the FCC. Because of our recent arrival on the scene, and since the rulemaking process is well along, it is unlikely that the TV Games Industry can affect the outcome to any great degree. We will probably have to live with whatever form Paragraph 15.7 takes for some time to come. However, the important Subpart H, which deals with TV games, is another matter. But before we get into that, let us look at the Industry's present situation from the standpoint of their efforts to design their product so as to gain Type Approval.

[1] Interim Report, Narrowband RF Emanations From Electronic Data Processing Equipment and Office Machines, CBEMA/ESC5/76/19, 30 July 1976

Some companies have attacked the Type Approval design problem in ways which are typical of production organizations suddenly faced with the requirement to incorporate a new discipline into their engineering capabilities. There is often a great deal of frantic activity by everyone, all trying to "contribute" by applying their pet ideas and intuitive concepts. There are exceptions, of course. Some companies understand that the concepts involved in the identification, location, and suppression of sources of electromagnetic emissions is an ability which comes from extensive engineering experience. If that capability did not exist in-house, they either brought it in, or hired a consultant. But others have gambled on the ability of one of their technicians or engineers to come up with some sort of miraculous fix, even though the individual had little or no experience, let alone a properly equipped laboratory. Today the FCC feels that the biggest single problem with the Games Industry is that companies come to them without either the requisite background of in-house expertise, or the support of an independent test laboratory which is both competent, knowledgeable, and properly equipped for the peculiarities of the Part 15 test procedures.

Considering the potential marketing impact of production holdups due to refusals of Type Approval by the FCC, there is little question that each company in the Industry must have access to competent engineering and well-equipped testing facilities, not only during the initial design phase and Type Approval exercise, but also during full production. There are two ways to obtain these capabilities. First, you can establish them in-house. To do this requires three things: (1) An experienced EMI engineer, (2) up to $75,000 of initial capital equipment expenditure, and (3) lab space and some sort of area for "open field" tests. To attempt to do the job by simply hiring an EMI engineer (or an EMI consultant) without giving him the tools is as unrealistic as expecting one of your design engineers to "pick it up" by reading a few articles and books.

The second approach to achieving Type Approval is to utilize the services of an independent test lab. Unfortunately, there are few labs which are properly equipped for this type of work. In order to be able to provide a high level of assurance that a particular game will, when submitted to the FCC, yield the same test results that the lab obtained, the lab must use the same equipment and procedures used by the FCC. Even then, because of the high degree of subjectivity in some of the test setups (especially in the radiated emission test), and variations in characteristics of the test equipment itself (especially in the signal line conducted test), there is still an unacceptably high chance that a game deemed "acceptable" by the lab's data will fail the FCC's Type Approval test. This is a very poor situation, and one that can be corrected only by concerted action on the part of the Industry to improve the applicable sections of the FCC's Rules and Regulations.

Let us now consider some of the problems in the Subpart H requirements which apply to TV Games. There are five types of tests covered by Subpart H:

(1) Measurement of the spectral amplitudes of magnetic or electric (depending on frequency) fields being radiated from the game (including ac adaptor, if so equipped, ANTENNA/GAME switch, and interconnecting cables).

(2) Measurement of the spectral voltages which appear on the ac or dc power line.

(3) Measurement of the spectral voltages which are applied to the terminals of the TV set.

(4) Measurement of the isolation of the "transfer" (i.e., the ANTENNA/GAME switch, at the channel frequencies for which the game is designed to be used.

(5) Measurement of the amplitude of the modulated carrier which is applied to the terminals of the TV set, at the channel frequencies.

Consider first the test which measures the levels of radiated electromagnetic emissions, number (1) above. The high degree of subjectivity in the method used to perform this test makes it very difficult for the engineer to know whether he has over or underdesigned. During the test, the FCC moves the various cables over and around the game in a variety of arbitrary configurations, looking for a "worst case" configuration. It is not unlikely that no matter how hard the manufacturer (or independent test lab) has looked for this worst case condition, the FCC, if they spend enough time at it, will be able to find a particular orientation of game and cables which results in a higher level of radiation than the lab found. In the context of EMI qualification testing procedures, this is the only radiation test in the world which allows the arbitrary placement of the various elements of the item being tested. But the only way in which this situation will be changed is for the Games Industry to research the alternatives, and to present these alternatives to the FCC in a "Petition For Rulemaking" procedure, complete with a strong technical rationale.

The second test in our list has a hidden pitfall for the Games Industry. In an effort to lower the per-unit cost, some manufacturers have offered various models in their line of battery-operated games for sale without an ac adaptor. Apparently they reason (probably correctly) that the game will most likely be operated on batteries by most purchasers, and that the few who do want to operate from household ac power can then purchase an optional ac adaptor. This being the case, there is no reason to make the majority of buyers pay for ac adaptors they will never use. However, in the Type Approval process, two games which are in all respects identical except for the inclusion with one of an ac adaptor, must according to the FCC, each undergo its own Type Approval. Now comes the clinker. Because of the nature of the test setup, the game which uses the ac adaptor will exhibit much lower levels on its ac power connection than the battery powered game will show on its dc power input (which

is provided for connection to an optional ac adaptor). In order for the manufacturer to get Type Approval of this game, he will most likely have to add extensive additional filtering to this dc power interface. This is clearly a case where the buyer is being penalized on the basis of a potential interference-causing condition which will never exist (unless, of course, he has a 6.3 Vdc outlet in the wall of his living room.) Again, this is a situation which will not change without a concerted effort by the Industry.

Now consider the third test in our list above. The procedures used by the FCC to measure the spectral (i.e., function of frequency) levels of electromagnetic energy which are applied to the terminals of the TV set are delineated in Paragraph 2.0 of FCC BULLETIN OCD 33, Dated May 1973, and entitled FCC TEST PROCEDURES FOR CLASS I TV DEVICES SUBMITTED FOR TYPE APPROVAL UNDER PART 15. Although the FCC apparently does not attempt to configure the various wires and cables, which form a part of the game being tested, to obtain a worst case configuration, experiments by the writer have confirmed that such configurations do indeed have a significant effect on the outcome. For us this is bad news, because here again the Rules do not precisely specify how the game is to be configured during the Type Approval test. This situation needs to be improved.

But there is yet another serious problem with this test. Because the spectral energy levels are being measured on the game's balanced 300-ohm output terminals, some sort of matching network is required to interface with the unbalanced 50-ohm-input of tuned RF voltmeters and spectrum analyzers. To achieve this 300-to-50 ohm match, the FCC is currently using a device (balun) which, according to its manufacturer, is not presently in production. (The writer's considerable efforts to obtain one of the devices, on a cost-is-no-object basis, were unsuccessful.) However, even if the device were readily available, its use for this particular type of measurement is questionable for a number of technical reasons. There are alternate ways for performing this test using readily available components, and experiments by the writer have demonstrated both feasibility and the simultaneous reduction in test setup variables. But in order to carry any weight, such experiments need to be formalized, verified by several competent authorities, and the results used as rationale for a concerted petition from the Industry to the FCC.

The measurement of Transfer Switch isolation is performed by the FCC using the same techniques as those used to measure the 300-ohm output spectral energy levels. The FCC is very concerned about the level of switch isolation, and rightly so. The switch is the only thing which prevents the RF energy generated by the game from being transmitted in a relatively efficient manner from the TV set's antenna. However, we are again faced with a situation in which variations in the test setup play a significant role in the ability of the game to gain Type Approval. (Currently, of all the Subpart H tests, the FCC seems to examine the Transfer Switch isolation with the greatest vigor.) Once again, it behooves the Industry to get together, and in a unified manner develop a technically justifiable test method which will permit us to accurately predict the ability of our designs to gain Type Approval before they are submitted.

Throughout this paper, the writer has repeatedly stated that the only way in which those portions of the FCC's Rules and Regulations which are applicable to the TV Games Industry can be improved is for the Industry itself to initiate the action. It does this by submitting a "Petition For Rulemaking" to the FCC. By law, this submittal will initiate a series of notices, reports, and evaluations which can eventually lead to an amendment of the Rules. So how do we get the ball rolling? The writer suggests the following three step program:

(1) An ad hoc committee be assembled consisting of representatives from each of the concerned manufacturers. The purpose of the committee will be to establish the basic objectives of the Industry in the area of its relationship to the FCC. The committee will also explore the possibility of forming a permanent CBEMA-type organization (on a much smaller scale, of course).

(2) A technical investigation effort, directed by the committee, be initiated to study and proof-test various alternatives to the Type Approval requirements and procedures. These tasks will be shared by the various participating members, and periodic meetings of the committee will digest and report on the contributions of the participants.

(3) An interface between the committee and the FCC will be established to ensure that the interests of both parties are considered, so that the probability of eventual improvement of the Rules and Regulations is maximized.

XII ADVANTAGES AND DISADVANTAGES OF MICROPROCESSORS IN COIN-OPERATED GAMES

CHARLES MC EWAN
Ramtek Corp.
Sunnyvale, California

Electronics first began to move into coin-operated games in the late 1960's. DTL was used successfully in a game developed in 1969 but the big move to electronics didn't occur until 1972 and 1973 when ping-pong type video games were brought by Atari, Ramtek and many other companies. During the following years, electronics was employed in many other kinds of games -- for example baseball. Some of these games were later redesigned to use DTL control logic or microprocessors.

The coin-operated game market is quite different in size from the home video game market. The worldwide market for coin-operated amusement games, not including pinball or flipper-type games and also excluding gambling games is about $75,000,000 a year. This marketplace consists of arcades, lounges, boardwalk amusement centers, etc. To the electronics industry, this represents about $14,000,000 of vendor-supplied electronics -- not an exceptional large market by itself.

If the pinball market is included, an additional $125,000,000 retail equipment business is involved. The pinball machine field is still holding out as far as electronics is concerned. A few companies have built some semi-electronic pinball machines, a few of much contain microprocessors. But none of the major manufacturers have produced a coin-operated microprocessor-controlled pinball machine.

When pinball machines make the switch to microprocessors the coin-operated game marketplace for electronics will increase to about $50,000,000.

All of the four or five different coin-operated games per year being developed by Ramtec are microprocessor controlled. There are several reasons for this.

The coin-operated game has a very short lifetime. Building time for a product if 90 to 120 days. The way a game is evolved is -- a breadboard is built, it is field tested or tested in-house, it is then redesigned and retested, taken into the field, two or three models are tested in several locations, more redesign and testing follow -- and then the decision is made whether or not to produce the machine. Every other product is cancelled at this point. If you're using DTL logic, this process takes a lot of time. Keep in mind, also, that not only electronics is involved, other changes, such as cabinet modifications may also be required.

By designing with microprocessors, particularly if a universal board is being used, the designer has a great advantage. Programs can quickly be changed and a large amount of the software is reuseable from game to game. It's not unusual, using microprocessors, to go from start to finish in two weeks. The player interaction and the game are carried out in new software.

Other functions may be accomplished by existing software. The game can reach field testing in three to four weeks instead of ten to twelve weeks. Typically one engineer and one programmer are involved in generating a new game instead of three engineers and two programmers. If a manufacturer isn't using microprocessors a competitor can quickly pass him by.

A successful run in the coin-operated game business is one that involves production of about 10,000 machines. A typical run for a game, field tested and accepted is 1500 to 3000.

Because time is so important, the reduction of in-house test time is one of the important advantages provided by the microprocessor. We have been using the 8080 in our game designs because we are very familiar with this device. Once you commit to a particular microprocessor, it is very difficult to change along the way. We have about $125,000 worth of test equipment for the 8080 including development systems and checkout systems -- it would be a very expensive change.

After we decided to use microprocessors in our game designs, we decided to develop a universal game board. After developing one game using this board, we came to the conclusion that we needed universal game board number two.

The first board had a large amount of RAM storage, not all of which was needed. The second board was a character generator oriented system and did not have as large a RAM base. After we started working on Horoscope we decided that we needed game board number three. This is a non-video control board -- it is used to control games with lots of interaction; it has a big I/O port and a fairly slow CPU.

Besides cutting down on labor and development and test time, the microprocessor also provides a servicing advantage. Nationwide, there are 40 to 45 distributors who handle coin-operated games. They are responsible to their customers for service. If it's a bad problem the game will be returned to the factory but normally the repairs will be carried out locally. Here is where the universal game board becomes important. If a universal board is being used, the maintenance personnel will become familiar with it and become proficient servicing games in which it is used.

Our universal boards include blank areas for adding ROMs or PROMs. The decision to use ROMs or PROMs is based on timing. In the coin-operated game business there isn't always sufficient time to mask ROMs so we go to bipolar fuse-link PROMs instead.

In designing our games we want the system to be able to operate with any commercially available 8080, with 2708 PROMs, fuse-link PROMs or programmed ROMs so that availability of product wouldn't be a problem.

XIII CONNECTORS AND SWITCHES FOR USE IN GAMES

DICK PIERCE
Molex, Inc.
Lisle, IL

During this seminar, we have heard about many new technological ideas and concepts which, I am sure, will motivate the creation of many new product designs. Implementation of new features can be accomplished easier through the use of standard interconnect systems.

Molex has two basic standard interconnect systems which have been used extensively in the TV and radio industry.

The first system is our plug-and-receptacle interconnect. Available in .093 and .062 diameters, this interconnect is used primarily for harness connections. Features of this system are: for the .093 series, molded housing in nylon and phenolic material are available in 1 through 60 circuits; for the .062 series, 1 through 104 circuits are available; all housings, with the exception of the single circuit, are polarized to prevent misconnections; additional polarization can be achieved by mixing the male and female terminals; crimp, PC tail and solder-loop terminals are available (crimp range is 14 AWG through 30 AWG). Standard terminal material is tin-plated brass; gold-plated and tin-plated phosphor bronze terminals are also available. Locking tabs and panel mounting ears are optional features.

The second system is the Molex KK interconnect. This system is designed to provide maximum design flexibility for cable-to-board, board-to-board and board-to-chassis interconnect. Properly applied, this can be the lowest applied cost in interconnect system.

These connectors feature in-line terminals on .200, .156, .100 and .098 centers.

PC tail and crimp terminals, which mate with square wires, incorporating a proven double cantilever, anti-overstress design provide high reliability in most environments including dry-circuit applications.

The crimp terminals can be crimped to 18 through 30 AWG wire. The square wires can be inserted directly into PCBs or pre-inserted wafers can be used, depending on volume requirements.

Molded housings are available to accept crimped terminals and fully loaded PC connectors featuring right angle, top and bottom entry.

For the two systems described, Molex has automation equipment which can significantly reduce your total applied costs.

Hand crimpers, bench crimpers and crimp dies fitted to wire preparation equipment (Artos, Eubanks, etc.) are available to reduce your crimping costs.

Automatic-terminal-insertion equipment is available and the Molex-A-Matic Mark II will sequentially cut wire to length, strip, crimp and insert terminals into housings, eliminating all labor costs for crimping and inserting.

Single pinsetters and multi-pinsetters are available with pantograph and X-Y tables to insert square pins economically into your PC board. For large volume, high-pin density applications, Molex has a vibratory system, which will mass-insert all the pins in one PC board or an aggragate of boards in one load cycle. Average cycle time is two minutes and can insert in excess of 3,000 pins per cycle.

In addition to our standard products, Molex has other special products including LSI and IC sockets, transistor sockets and edge connectors.

New products which will be applicable to the electronic games industry are:

<u>The 4706/4811 PC Terminal</u>

The 4811-0 and 4811-1, 4706 and 4706-3 terminals are used to secure #16 through #26 AWG wire leads to a printed-circuit board prior to soldering and offers the following advantages:

Elimination of leads falling out of the printed-circuit board holes during component insertion and handling prior to soldering;

The terminal construction allows the actual wire lead to be soldered; and because the terminal fills the printed-circuit board hole, solder voiding is minimized;

Due to the low-insertion force, wires with crimped 4811, 4706 type terminals can be inserted into the printed-circuit boards at any time during assembly and prior to soldering without causing adjacent components to "pop" out of the printed-circuit board due to excessive board deflection;

After soldering, the insulation crimp creates an effective strain relief;

Need for pre-affixed eyelets or griplets on the printed-circuit board is eliminated;

Designed to fit into standard .049, .093 and .073 hole diameters in .062 $\pm$ .008 thick PC board.

Flat Conductor Connector, 4850 Series

The 4850 connector enables the designer to use flat-conductor-ribbon cable or flexible-etched circuitry in a variety of new designs. It is available in gold or tin and features a very low contact resistance. A novel hinging mechanism assures that each terminal makes positive contact with the corresponding pads on the flat mating conductor. The design eliminates two connectors in every interconnecting cable scheme. The design is on .100" centers and can be mounted parallel to a PC board or vertically to it. Production sizes are 5 through 25 circuits, inclusive.

Zero Insertion Force Cable Connector 4346 Series

This unique design incorporates a moving housing actuated by a cam, which assures up to 36 contact mating with zero insertion force. The design enables the packaging engineer to consider a pin-type connector mounted directly on a PC board. The zero insertion and withdrawal force prevents damage to PC boards usually occurring when multiple pins are engaged using conventional connectors. It is available in either tin or gold plating and utilizes a unique flat-blade contact that is interchangeable on both halves of the connector.

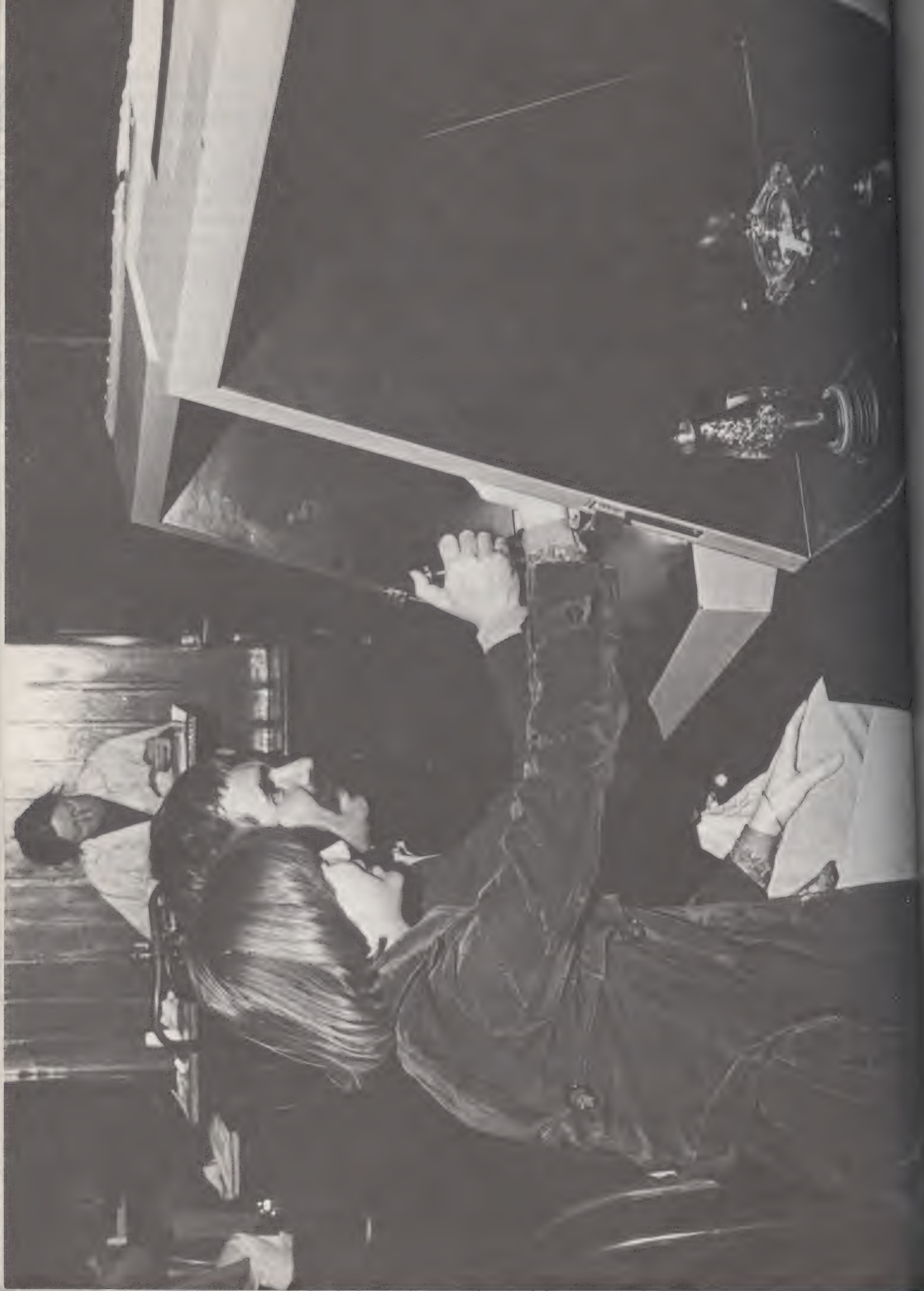
Commoning Connector, 1461 Series

An innovative design results in a commoning block that uses a single, common terminal and one plastic housing. All terminals are rated at 12 amps, 30°C temperature rise, UL listed. Housing material is 94 VO polyester. Connectors can be stacked side by side, interlocked. Commoned circuits within a given commoning block can be separated by an insertable and removable plastic insulation key. The design simplicity results in a highly functional part at a very attractive price.

Designers normally try to design in as many standard products as possible. However, there are applications where a modification of an existing part or totally new device would enhance the total design in regards to improved features, lower material and/or manufacturing costs and serviceability.

In these cases, Molex is ready to assist your engineering staff to produce the most viable product to meet your needs.

Simple additions of mounting ears to totally new products such as transducer mountings, lamp driver sockets, and low insertion force edge connectors are totally within the scope of Molex engineering.



XIV TV GAME BACKGROUND

JERRY EIMBINDER
Electronic Engineering Times
Great Neck, New York

In 1962, a graduate student at Massachusetts Institute of Technology named Steve Russell wrote a computer program for a game called Spacewar. Research buffs estimate that Russell's ingenuity cost companies possessing computers several million dollars during the following three or four years.

In order to play Spacewar, engineers and other employees of companies having computers had to obtain computer time one way or another. Some returned to the plant with the late shifts and guided rocket ships across computer displays until nearly dawn. Others found more devious or round-about ways to use their company's computers.

Spacewar continued to be popular through the late 1960's. At this time, two of the students who learned the game on the college campus were Nolan Bushnell at the University of Utah and Bill Pitts at Stanford's Artificial Intelligence Center.

Both Bushnell and Pitts independently set out to develop commercial versions of Spacewar. Bushnell's model "Computer Space" was finished first, in 1970 by his company, Atari.

Although Atari didn't actually produce the game (the rights were sold to another company), it learned much about user interest from studying the reaction to Computer Space in the marketplace. Computer Space wasn't a heavily successful financial venture because it was too complicated and taxed the player's mental powers to understand it.

The situation was totally different for Pong. Because of its similarity to Ping-Pong, the player was able to grasp its principles immediately.

Atari field tested Pong in 1972 by installing its prototype unit in a bar in Sunnyvale, California called Andy Capp's.

The machine ceased working after two days and Nolan Bushnell stopped by to see what was wrong. A complete check of its TTL logic circuitry uncovered nothing wrong and finally Bushnell checked the coin box. It was jammed to capacity. Bushnell then knew that he had a likely winner.

Meanwhile, Pitts completed a prototype unit in 1971 and followed with a second model called "Galaxy Game" a year later. He placed it in the Tressider Union Coffeehouse at Standford, a few miles from where Bushnell's Pong game was under evaluation at Andy Capp's. Pitts' game, employing a Digital Equipment Corp. PDP-11 computer, challenged some and discouraged many. The machine still stands there today. No

---

Galaxy Game being played at the Tressider Union Coffeehouse.

more have ever been built.

Computer Space, while more successful than Galaxy Game, proved a disappointment financially. The failure of both games to revolutionize leisure-time habits is attributed both to the time required to learn how to play and the mental capability needed to play well.

The score in the TV game evolution was one successful idea and one failure.

The paddle game would survive and prosper. In 1972, Magnavox made history with its announcement of Odyssey and in 1973, Universal Research, a manufacturer of coin-operated arcade games also introduced a paddle-principle home video game.

Nolan Bushnell went on to build Atari into a major factor in the electronic games industry. Besides producing coin-operated machines, he moved Atari into the home video game business in 1975, marketing Pong through Sears and Roebuck stores. He received one of the two 1977 awards at Gametronics for pioneering efforts in the electronics industry.

The other award was given to Ralph Baer, currently manager of consumer electronics development at Sanders Associates.

Baer first began working on a prototype for a TV game in late 1966 although the idea had crossed his mind many years before. He had an unusual background which particularly qualified him for the accomplishments he was to later achieve. Several years earlier in his career, Baer had been given the assignment by a New York military systems company, eyeing the consumer marketplace, to design the world's best television set, sparing no expense.

But when the design was complete, Baer's employer decided that the necessary selling price was too great an obstacle to hurl. The prototype was the only unit to be built; the project was abandoned.

However, Baer had acquired incredible knowledge of possible, as well as actual, performance obtainable from a television receiver.

By 1966 Baer had advanced to the position of division manager for the equipment design division of Sanders Associates, Manchester, New Hampshire, supervising a staff of up to 500 engineers and technicians. More important, he was now in a position to authorize work on TV games.

In early 1967, Baer hired engineer Bill Harrison to begin full-time TV game development. Shortly after that, he also added engineer Bill Rusch to the project.

Baer assigned Harrison and Rusch to an enclosed 10 x 15 ft. office containing two desks, a workbench and support electronic equipment. The door was kept locked at all times; only Baer, Harrison and Rusch had keys.

The project was a closely guarded secret, although the area was referred to as "The Game Room." Because Harrison and Rusch had a habit of playing recorded guitar music while working, most fellow employees assumed that the room was being used to develop an electronic guitar.

"We had bought an RCA 17-inch color TV console set in 1967," says Baer, "and, believe it or not, here we were fully ten years ago, playing chase games, target games, and, a little later on, the first fully interactive ping-pong and hockey games with color and FM sound through the TV set. Even our earliest ping-pong games were played against a green background, while, naturally, hockey was played against a background of blue ice."

A working multi-game model was completed in mid-1967 and Sanders Associates began looking for licensees. Demonstrations for potential customers continued through 1969 when, after a deal with RCA fell through at the last minute, an agreement with Magnavox was arranged.

Magnavox demonstrated the Sanders-developed game in May, 1972, and had established substantial production line capability by the summer of 1972. Nearly 100,000 Odyssey games were sold that year.

The first Odyssey game, introduced in 1972 by Magnavox, contained approximately 305 discrete parts in its master control unit and hand controls. Overlays for placing on the television set screens were supplied with Odyssey to simulate field backgrounds. The Odyssey package also included dice, poker chips, play money, card decks and game boards. Twelve games, many very similar, were offered.

Acceptance was gradual. Some of the reasons that have been advanced for Odyssey's failure to skyrocket in sales more than it did after its introduction include too many auxiliary components, inadequate promotion, and belief that it could only be used with a Magnavox television set.

Magnavox was also beset with other problems during the period following the introduction of Odyssey. It had delayed in converting its television line to solid-state devices when competitors began moving in this direction. In its rush to catch up, it experienced serious conversion problems and its reputation suffered badly. Its consumer electronics operation, which had recorded a $22 million profit in 1972, dropped to a $5.8 million loss in 1973, and then plunged to a $42.1 million loss in 1974. It remained in the red in 1975 with a $10.3

deficit. But, through its problems, its management didn't lose faith in Odyssey.

The first version of Odyssey was manufactured until 1975 when large-scale-integration (LSI) parts became available. Based on the use of nine complex semiconductor chips, two improved versions of the 1972 model were designed.

The use of the nine LSI chips, custom designed for the new games, cut the total number of parts needed to approximately 200, thus reducing assembly cost and time.

Several advanced integrated-circuit technologies included newly developed integrated injection logic (I^2L) were employed in the nine chips.

The first chip provides five basic functions: power supply regulation, top and bottom rebound circuitry, wall generator, horizontal sync, and vertical sync generation.

The second generates the ball and also, slaved with the first chip, is a wall generator. The third chip is the ball generator.

The logic and video summing circuitry is contained on the fourth chip. This chip detects coincidence between the players and the ball and determines the course that the ball will follow.

The fifth and sixth chips are assigned to score keeping.

The seventh chip drives the eighth chip, a character generator, which develops a matrix pattern.

The video outputs from the other eight chips are fed to the ninth chip which produces a composite color video signal.

By appropriate selection from the master set of nine chips, 18 possible combinations of chips exist that could form different video game systems.

Subsequently, in 1976, Magnavox further cut the number of components needed to build a video game to 75, by introducing a single-chip LSI system. The chip contained all of the spot generator, logic, sync, multitone sound and digital scoring circuitry but offered less flexibility than provided by the multichip system.

Prior to the development of one-chip game systems, a number of companies were testing the marketplace for TV games with models using TTL circuitry. One of these companies was First Dimension Corp. founded in mid-1975 in Nashville by Norvell L. Olive. First Dimension manufactured 7000 games in time to ship for the Christmas 1975 season. Next, preparing for mass-volume production of its $129 game in 1976, it

purchased $1.5 million worth of parts.

But in early 1976, General Instrument introduced the product that changed the nature of the video games industry.

General Instrument put most of the circuitry needed for designing a video game on a single chip, the AY38500. The game designer was provided with one chip which provided four paddle games and two different rifle games. In addition, capability for fast ball and slow ball, steep angle and shallow angle, and long paddle and short paddle operation was offered.

For companies thinking about going into the TV game business, the GI chip was the convincer. For First Dimension, sitting with a hugh inventory of discrete parts, it was a crushing blow.

The cost of the GI chip ranged from $5 to $6 depending on the volume involved. It promised total system costs of $25 to $30 and retail prices in the $60 to $75 range.

Development of the chip had been initiated for Salora OY in Finland for use in a television set; subsequently Telefunken GmbH and Loewe-Opta GmbH in West Germany and Vanguard S. A. in Spain had also ordered the device. In order to market the IC in the U. S., General Instrument's Hicksville, New York plant developed a 525-line, 60 half-frames-per-second NTSC system version of the original chip, designed for 625-line, 50-half-frames-per-second PAL systems in GI's Glenrothes, Scotland plant.

The GI chip made it possible for companies to quickly establish simplified production lines and to build games that would sell for well under the $129 asked for First Dimension's game.

Pressured by creditors, who held $2 million of redeemable preferred stock in First Dimension, the company filed for operation under bankruptcy as provided for by Chapter XI. Revival seemed possible in September after lawyer John J. Hooker Jr. borrowed and invested $500,000 in First Dimension and the bankruptcy judge delayed redemption of the preferred stock until the end of 1976.

But Hooker's infusion money was rapidly whittled down by $300,000 worth of new bills requiring immediate payment and staggering lawyer's fees. By late October, First Dimension ran out of operating funds after building only 20,000 of its planned 300,000 production run and reaching only $900,000 in sales.

Hard times loomed ahead for many other video game builders. Publicity about First Dimension's troubles spread among suppliers. Many small games companies found they couldn't get parts unless they paid in advance. Some folded in a

matter of weeks or months after their founders ran out of cash before sustaining income was received. Others learned, sometimes belatedly, that the demand for the General Instrument chip far exceeded the supply and other integrated-circuit suppliers weren't ready to fill the void. Lloyd's Electronics says it received only 20% of the chips it had ordered from General Instrument for games planned for the Christmas 1976 season.

The supply of games ran short during the Christmas 1976 season in some parts of the United States.

Lloyd's feels it lost about $15 million in sales when Systek Corp., its Japanese assembler, ceased production because of financial problems and didn't resume operations until the Christmas season had passed.

Coleco was the first major customer for General Instrument's industry-revolutionizing game chip and as a result received early delivery of the part. Approval for its game also came early from the Federal Communications Commission, and by May, 1976, many stores had sufficient stock to meet Father's Day demands. Reorders poured in, encouraging Coleco to build up heavy production capability.

Coleco president Arnold Greenberg estimates that his company's 1976 games sales exceeded $110 million.

Even before the Christmas 1976 season, the momentum was clearly evident. By the middle of 1976, approximately 70 companies were in the home video game business.

Atari, recognizing that the battle ahead would be awesome, began looking for a way to raise more capital. It received the financial backing it needed to broaden its activities in the fall of 1976 when Warner Communications paid $28 million to take ownership. Bushnell continued in his post of Atari board chairman.

Sales for the TV games during the Christmas 1976 holiday season lifted the industry into the big business category.

A survey of game manufacturers, conducted by hfd-Retailing Home Furnishings and published in its January 13, 1977 issue, indicated that TV game sales in 1976 were approximately $187,000,000. Estimated unit sales were 3.39 million.

Projections by manufacturers for 1977 see units shipped rising to 8.14 million with sales ranging from $270,000,000 to $500,000,000.

Also providing evidence that the industry had stabilized and could offset bad publicity was reaction to the ion burn scare.

The discovery by T. Eaton Co., a Canadian department store chain, that two of its floor-model television sets had permanent imprint burns, received widespread publicity.

The two sets, both black-and-white models were operated 12 hours a day for five weeks. Although the Eaton disclosure did not hurt sales, it triggered a probe into ion burn damage from prolonged operation by the Federal Trade Commission. It also prompted some stores, including Eaton's and some manufacturers to issue warnings against operation at full brightness or full contrast over extended time periods.

The first home TV game system to accommodate replaceable cartridges was introduced by Fairchild Camera and Instrument in August, 1976. The unit has hockey and tennis built in. The key to its versatility, however, is its capability to accept a never-ending number of new cartridges as they are developed.

Each Videocart cartridge contains a semiconductor memory programmed to reproduce specific games on the television screen in full color. The game console uses a Fairchild F8 microprocessor and four semiconductor random access memories to provide the basic game system electronics. For sports games, the score and elapsed time are displayed continuously at the bottom of the screen.

Scheduled to follow Fairchild into the plug-in-game business is RCA, which has developed a microprocessor-based system using the 1802. The RCA unit will combine keyboard console control with read-only-memory cartridge game inputs. Bowling is among the games being offered by the RCA system.

XV. TRENDS IN TV GAMES

JERRY EIMBINDER
Electronic Engineering Times
Great Neck, New York

Projections for video game sales vary widely. Depending on who is doing the forecasting, TV game sales range from under $400 million to more than $1 billion by 1980. Some researchers project video game sales reaching a peak in early 1979 and then declining because of inroads by home computers.

Projecting marketplace sizes is a tricky business. In the early 1960s, for a time it was believed that the tunnel diode would become the workhorse of the semiconductor industry and would displace transistors in circuit applications ranging from radio receivers to military systems. The tunnel diode, however, never reached the performance capability anticipated for it and, although it is still used today, is advantageous only for a handful of applications.

Several factors will have significant bearing on the size of the TV game marketplace during the next five years. First, of course, will be the extent of the impact of the home computer. Prices for home computers, in 1978, only a year ago, were projected to range from $1200 to $1500. But in February, 1977, Commodore announced that its home computer PET would become available in July at a price of approximately $450. At the same time, National Semiconductor revealed that it was testing a prototype home computer, available possibly as early as June, 1977 with an anticipated price of $300.

Because playing games will be one of the functions provided by home computers, many students of the games industry feel that the TV game as an independent system may be short lived.

There are opposing viewpoints. Just as many households today have two or three television sets, it is argued that the coexistence of a home computer with one or more TV game systems makes just as much sense.

Of course, in the history of the electronics industry, many advancements have resulted in the superceding of earlier developments. On the other hand, despite the purchase of $4.2 billion worth of television receivers in the U. S. in 1976, consumers also bought more than $800,000 worth of radios. From a standpoint of units sold, the number of radios purchased during 1976 is roughly equal to the number of TV sets purchased.

The public, in fact, also purchased $2.5 billion worth of audio equipment and spent approximately $2.8 billion for other consumer electronics equipment. Anyone that might have been worried, a few years ago, about the impact of color television on the rest of the consumer electronics

marketplace, can see from table one, it is alive and healthy today.

At the present time, the TV game marketplace shows no sign of doing anything but increasing sharply. Projections for 1977 TV game sales are in the order of $425 million, which will, in all probability, propel game sales past electronic calculator sales. Had any forecaster projected this a year ago, his sanity would have been questioned. By the way, the 1977 sales forecasts (see table two), indicate that microwave oven sales will reach $800 million in 1977. However, two years ago there was grave question if this industry even had a future because of some reports about microwave ovens causing cataracts and other injuries due to radiation leakage.

One research organization, Frost & Sullivan, warned in a recent report that TV game sales predictions were misleading and that it didn't anticipate the major marketplace evolution that others were forecasting. Our indications are entirely opposite. The feeling by many that the TV games industry will reach $1 billion in retail sales in 1980 is shared by the research department of Electronic Engineering Times.

As indicated in table three, sales of home TV games should rise from approximately $187 million in 1976 to $425 million in 1977. This represents an increase in unit sales from 3.39 million to 8 million.

Retail prices will make TV home games very affordable. Magnavox, for example, is preparing to supply a 24-game, 4-hand control color system in September 1977 priced at under $100. This non-programmable system will include the conventional paddle games (tennis, hockey, etc.) plus basketball, volleyball, helicopter, and tank games. National Semiconductor is scheduled to bring out its next generation of Adversary in June, which adds three new games including a simulated pinball machine game to existing games with no changes in its existing model -- a new chip is the only change required and it will replace the current chip, which is socketed (not soldered in) the circuit.

The price for a programmable game, although still rising in 1977, is expected to begin dropping sharply by 1978. In a similar manner, the cost of replaceable cartridges will also drop. The first programmable system, Fairchild's video entertainment system, was priced at $155 for the basic system and $20 for each additional cartridge purchased. During 1978 it is likely that similar systems will sell for $65 to $75 and cartridges will be well under $10. As shown in table four, prices for programmable games should continue to drop through 1980.

Stiff competition in the TV game industry is likely to force many small companies out of the running during 1977 and 1978. On the other hand, as more semiconductor manufacturers follow General Instrument into the game-on-a-chip business

survival may well depend on mass marketing capability combined with volume production expertise. Magnavox, the leader, and Atari, a close runner-up, in 1976, in terms of units produced, could be challenged by many companies not even in the TV games business today. TV game sales for leading producers are listed in table five.

Atari, strengthened by being acquired by Warner Communications, is believed to have commanded top spot in the TV games industry, moving past Magnavox, the previous year's leader. The ranking of the top producers, as shown in table five, actually shows Coleco with more sales than Magnavox or Atari. This information is based on unit sales reported by the game manufacturers to Creative Strategies, a West Coast company specializing in market studies.

HFD came up with another set of figures when it contacted each of the TV game manufacturers to estimate what they thought the industry did in units produced in 1976. Guesses ranged from 2.3 to 5.0 million units; the concensus was 3.39 (see table seven). HFD also came up with industry estimates for 1977 ranging from 4.5 to 12.5 million units (see table eight). The concensus for the companies supplying statistics was 8.14 million.

It is still difficult to determine the number of companies currently manufacturing video games. Some companies have folded after only three or four weeks of operation. Others have been in and out of the business two or three times during the last twelve months. The table of 80 TV game manufacturers (see table nine) compiled by Electronic Engineering Times was probably out of date the day after it was typed.

The projections that have been examined in the preceding paragraphs are for the home TV games market. The coin-operated electronic game marketplace (excluding pinball or flipper-type games and gambling equipment) is currently estimated at about 75 million. The principal manufacturers supplying this industry are shown in table nine. According to Charles McEwan, president of Ramtek, typical production runs for coin-operated TV game machines run in the 1500 to 3000 game range.

It's possible that non-TV electronic games, as they become more and more sophisticated, could provide serious competition with TV games for the consumer's dollar. For example, Mostek developed a highly acclaimed chess game in 1976, which still has not reached the marketplace, but which is considered a highly promising consumer product. Because it can be programmed to play the user at eight different levels of proficiency, it has more appeal than the one-level-of-skill models currently available.

Other examples of non-TV electronic games are the pocket-type calculator games introduced by Mattel. Mattel's Football and Auto Race both use calculator-type LED displays and retail in the $25 to $35 range.

Pocket and programmable calculators are also potential rivals. In March, 1977, Hewlett-Packard introduced a collection of games, prerecorded on magnetic cards, for use with its HP-67 and HP-97 calculators. Its first library, priced at $35 contains 19 programs (see table eleven).

Many of the games in the library can be played with two or more participants; six of them allow the degree of difficulty to be varied, some involve two people with calculators playing against each other. Only two of the games rely totally on chance for their outcome. "Dice" and "The Dealer" can be used to play a variety of games, since they display random dice rolls or card hands.

Certainly, developments in the consumer electronics industry such as the home computer, non-TV electronic games (electronic board games) and calculator programs are going to affect Father's Day, Christmas, birthday and no-occasion sales of TV games. In addition, other manufacturers may follow Magnavox into the manufacture of television sets including built-in TV games. Nevertheless, the video game industry appears certain to continue its dramatic upward sales pattern through 1980 when achievement of $1 billion in retail volume is reached.

Television Receivers	$4.2
Audio Equipment	2.5
Other Consumer Equipment	2.8
Total	$9.5

Table 1. Major Consumer Electronics Markets (In billions of dollars).

Microwave Ovens	$0.8
Electronic Watches	0.5
Electronic Games	0.425
Calculators	0.4
Musical Instruments	0.3
Miscellaneous	0.375
Total	$2.8

Table 2. Other Consumer Markets (In billions of dollars).

Year	Unit Volume	Total Sales
1980	17	$625 to $1000
1979	16	700
1978	12	575
1977	8	425

Table 3. Projected Game Sales (In millions of units and millions of dollars).

Year	Dedicated Games	Programmable Games
1980	Under $25	Under $50
1979	$25	$50
1978	$30	$65
1977	Over $35	Over $100

Table 4. Projected Retail Prices.

		Nov. '76	Feb. '77
1.	Magnavox	615	625
2.	Atari	600	650
3.	Unisonic	450	300
4.	Coleco	425	925
5.	Others	3750	--
	Total	3750	

Note: First column shows projections; second column shows figures subsequently reported.

Source: Creative Strategies, Inc.

Table 5. Estimated 1976 TV Game Sales by Company in Thousands of Units

	Per Cent of Market In Units		Per Cent of Market In Dollars	
	Nov. '76	Feb. '77	Nov. '76	Feb. '77
1. Atari	18	17	17	15
2. Unisonic	17	14	16	12
3. First Dimension	13	0	13	0
4. APF	12	10	12	9
5. National	9	9	10	9
6. Magnavox	8	11	8	12
7. Fairchild	7	--	10	--
8. Coleco	6	18	5	17
9. RCA	4	3	4	5
10. Others	6	--	4	--

Source: Creative Strategies, Inc.
Note: Revised figures issued in February reflect financial difficulties encountered by First Dimension.

Table 6. Estimated 1977 TV Games Sales By Company

Manufacturer	Unit Volume (mil.)	Average Retail Price	Total Sales (mil. $)
Universal Research	5.0	--	--
Coleco	4.0	$60	$240
General Instrument	4.0	--	--
APF	3.75	$65	$244
Magnavox	3.0	$67	$200
Fairchild	2.5	$40	$100
Unisonic	2.5	$75	$188
Atari	2.34	$64	$150
Consensus	3.39	$61.83	$187

Source: HFD, January 13, 1977, p. 61

Table 7. 1976 TV Game Industry Estimates

Manufacturer	Unit Volume (Mil.)
Universal Research	12.5
General Instrument	11.0
APF	10
Atari	7
Coleco	7
Fairchild	5
Magnavox	4.5
Consensus	8.14

Source: HFD, January 13, 1977, p. 61

Table 8. 1977 TV Game Industry Projections

Accurate
Action Games
Advanced Electronics
Advanced Microcomputer Products
Allied Leisure
Amcor
American Consumer Electronics
APF Electronics
Atari
Bally Manufacturing
B&B Import
Broadmoor
Cal Kit
Century Industries
Channel Master
Coleco (Telstar)
Concept
Continental Microsystems
Diamond Electronics
Digital Games
Digitek
DYN
EBSCO
Electra Games
Electronic Resources Ltd.
Enterprex
Entex
E&P
Executive Games
Exidy
Fairchild Camera & Instrument
Fantasia
Federal Transistor
First Dimension
Fried Trading
Fun Games, Inc.
General Home Products
Global Video
Gulliver
Hanimex
Heath
IEA
Intercon Marketing
Interfab
Internet
Interstate Industries
Jade
James Electronics
Kendale Technology
Kingspoint
Leisure Sports Systems
Lloyd's
LTA
Magnavox
Matsushita Electric
Mego
Microelectronic Systems (RicOchet)
Monte Verde
Morse
National Semiconductor
Northeast International
Phoenix International
Phone-Mate
Quadtronics
Radio Shack
Radofin
RCA
Sands Electronics
Shark Electronics
Sound-Mate
Southwest Technical
Tele-Match
Tokyo Phoenix
Unisonic
Universal Research
Venture
Video Cybernetics
Videomaster
Viking
Visulex

Table 9. TV Home Game Manufacturers (including companies with prototype developmental models).

Action
Allied Leisure
American
Atari (Kee)
Bally (Midway)
Century
Computer Games
Digital Games
Ebsco
Edcoe
Electro
Exidy
Fun Games
Gremlin
Innovative Coin Corp. (ICC)
Leisure Sports
Mirco
Project Support Engineering
Ramtek
Sega
UBI
Universal Research
U. S. Billiards
Venture Technology
World Wide

Table 10. Coin-Operated Video Game Manufacturers.

(RicOchet)

1. Game of 21	10. Tic-Tac-Toe
2. Dice	11. Wari
3. Slot Machine	12. Racetrack
4. Submarine Hunt	13. Teaser
5. Artillery Game	14. Golf
6. Space War	15. The Dealer
7. Super Bagels	16. Bowling Scorekeeper
8. NIM_k	17. Time-Stopwatch
9. Queen Board	18. Hexapawn

Table 11. Collection of Games, Pre-recorded on Magnetic Cards, for use with Hewlett-Packard HP-67 and HP-97 Pocket and Programmable Calculators.

XVI. VIDEO GAME CONTROLLERS

VICTOR KLEY
I Corporation
San Francisco, California

Flat panel graphics input tablets have been the device of choice whenever fast accurate positioning has been a design requirement. From a human engineering viewpoint, the flat panel provides a familiar user environment where the natural skills of drawing and writing may be readily utilized. In the past, flat panel input devices have suffered from two major failings - complexity and cost. Flat panel devices costing several thousands of dollars and having complex outputs have not found any widespread application.

For the first time, designers may look to flat panel devices costing less than two dollars. These new input devices, trademarked Joypad, emulate joystick functions and feature flat panel or pad-like architecture. Joypads are inexpensive and simple to use; they are capable of replacing conventional potentiometers in control applications. Made in a wide variety of sizes and having low profiles (approximately 1/10 inch), the graphics input device is available with the linearity and resolution to meet any control, or digitizing need. In addition, a clear device which is flexible and has a thickness of 1/20 inch or less will soon be available to meet a broad range of applications, including CRT overlays, menu overlays, positional input and plotting on three dimensional surfaces.

One exciting application of the joypad is in the area of character recognition. The microprocessor revolution has made immense computing power feasible for general application, but the ASCII Keyboard is both cumbersome and expensive. The use of a joypad for graphics input permits simple character recognition with personalized sequencing, for example a library of users may be built with 10 point character recognition algorithims. By eliminating the keyboard, the mechanics and cost of any microcomputing systems, such as one designed for home use, can drop to the $100 to $200 range necessary for a real growth in general use. The fact that data is input by writing on a tablet means that the naive user will not be threatened or frustrated by an imposing array of keys and switches. Studies[1] have shown that cursive writing is the preferred

form of communication even over the spoken word for long communications.

STRUCTURAL AND DESIGN CONSIDERATIONS

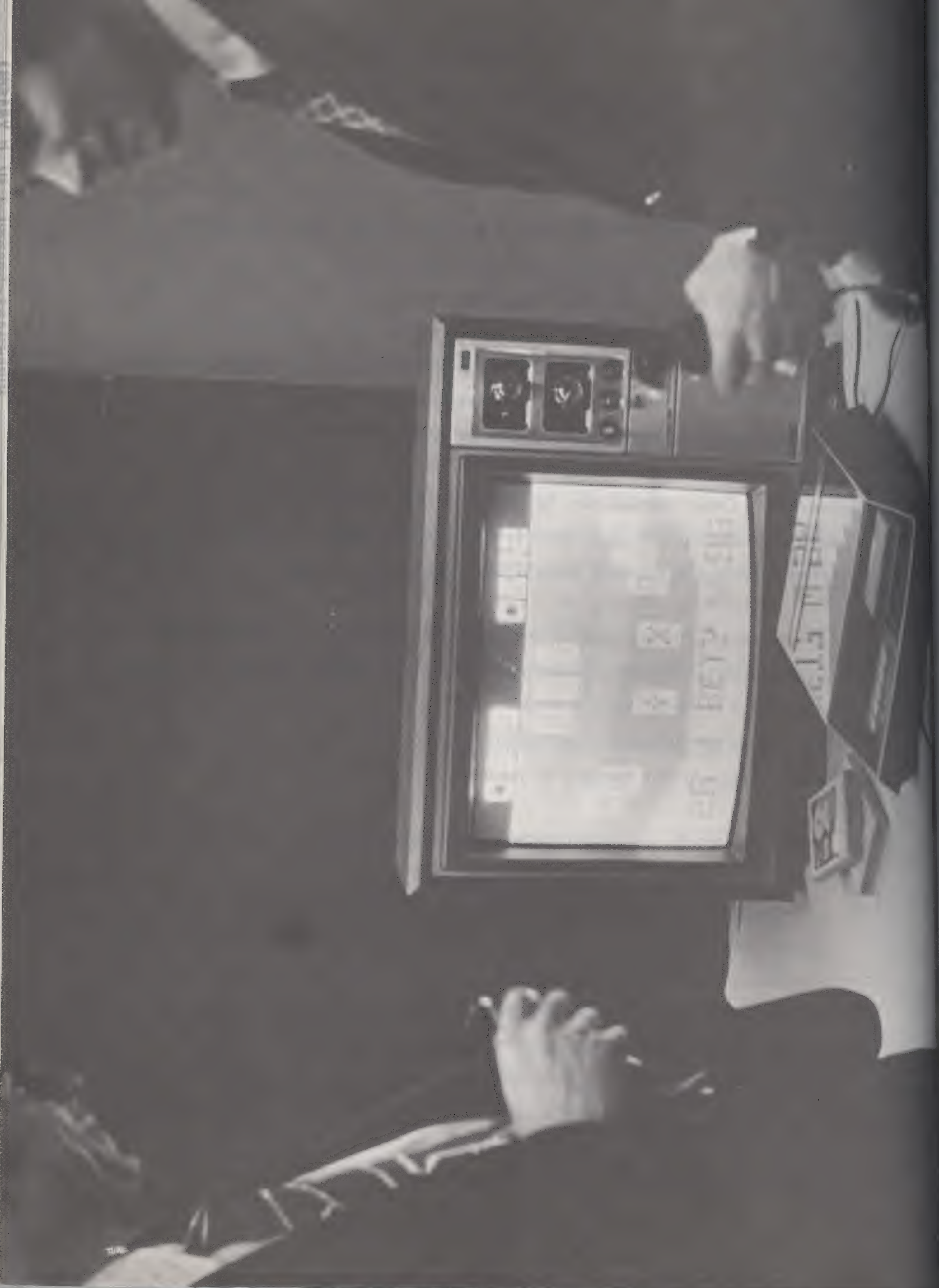
Having a profile of only 1/10 of an inch, the joypad is an optimum mechanical structure to be wed with L.S.I. (Large Scale Integration) printed circuits boards since such boards stack most naturally as planes. In fact, the economics of P.C. manufacture and product testing suggest that 8" X 10" or 10" X 10" configurations are the most cost effective. The joypad, in conjunction with P.C. boards, allows the construction of a shallow, light weight housing in which a minimum of material is used. In addition, the joypad may readily be used to perform simple (up to 5) switching functions without modifications. Other switches may be employed with the device in one joypad using the same technology to perform coded digital switching or other complex switch functions thus further simplifying total package design.

The joypad is available in P.C. mount, edge card, or solderable flex circuit output configurations, lending itself to conventional assembly techniques.

Top or sub surfaces of the joypad may be silk-screened making the unit adaptable for the purposes of product distinction.

ENVIRONMENTAL PROPERTIES

The packaged joypad is hermetically sealed protecting it from damage by most common liquids and abrasives. Top surfaces besides standard vinyl or polyester materials may be specified; surface fabrics such as teflon leave the joypad immune to cigarets and matches. Mechanically the joypad is as impact resistent as the surface it is mounted on. The joypad substrate may be either flexible or rigid giving the designer the ability to mount on either flat or slightly curved surfaces.



ELECTRICAL SPECIFICATIONS AND INTERFACING

The joypad is available in both digital and analog form.

The standard digital joypad has a four bit bus structure with a single strobe line (strobe high or low) for a total of five lines. The pad presents approximately 30 pf of input capacitance to the strobe line and is guaranteed to have no more than 75 ohm closed resistence after one million operations (average resistence is 5 ohms). Therefore, two digital joypads may be connected to a standard 8 bit microprocessor bus with the strobes on the address bus without loading most common MOS microprocessors. Obviously, the digital joypad may also be used as a simple switch closure in other logic systems. The maximum source current from the device is 100 milliamperes.

The analog joypad, like the digital device, is not restricted in its application. For instance, the analog joypad is available without cover or wiper so that it may be used with other mechanical wipers in process control or as a guide feedback circuit for precision plotters etc. Let me stress that the analog joypad is nothing more than a homogeneous resistence which has been linearized to two orthogonal connections and that therefore it may be used in any manner that the fertile mind of an engineer might conjure for a device with its electrical and mechanical properties. It is not even necessary to mechanically wipe the joypad in order to use it.

The clear joypad is nothing more than the standard joypad with a transparent homogeneous resistence and a layer of dielectric protecting the resistence. Position is coupled out of the device capacitively and translated as either amplitude (the amplitude of the derivative of the impressed voltage) or phase information. The capacitive coupling may be by probe or a finger used as a probe. The dielectric used in the clear joypad is washable and scratch resistent while the total pad thickness is approximately .050 inch which minimizes location

Black Jack is offered on a Fairchild Video Entertainment System cartridge.

errors due to paralax. The clear analog device is also available on a glass substrate.

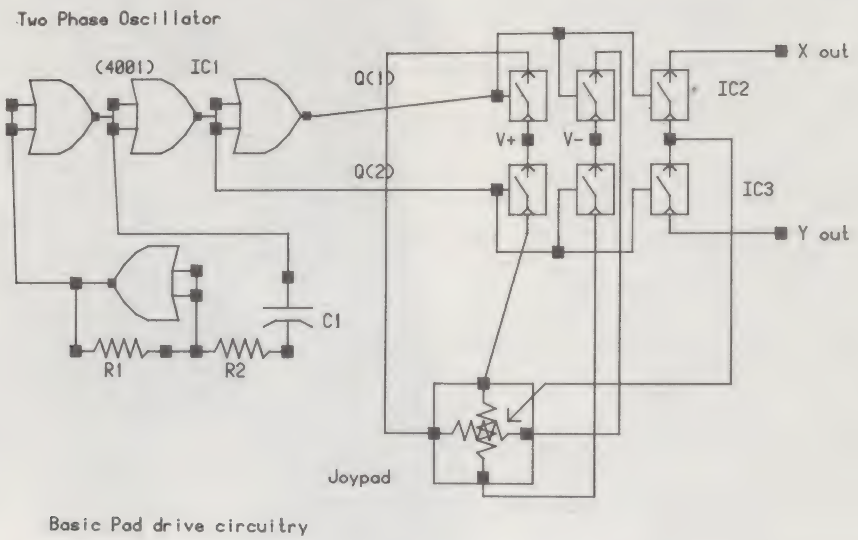
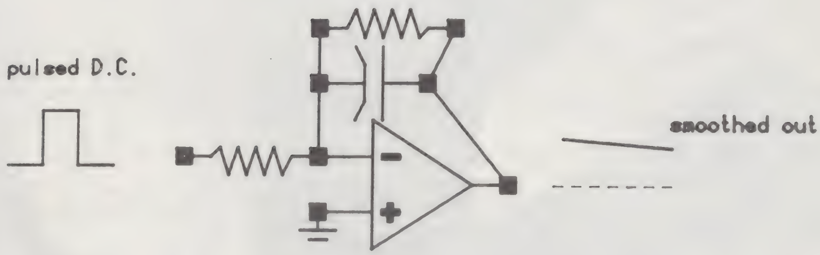


Figure #1



A lag lead element may be used to smooth the x and y pulses for systems which must see a D.C. level.

Figure #2

To demonstrate that not all electronic games are TV games, a couple of skits at Gametronics involved mock three-dimensional electronic dolls. Lisa, posing as an electronic doll, popped from a gift box.

Electrically, the joypad emulates two potentiometers with a common wiper (see Figure #1), and that is precisely the symbol we have adopted for it. The simplist method for using the pad involves placing two sets of diodes across the orthogonal axes and impressing an alternating voltage across them, picking off X and Y information on each half cycle. The method outlined in Figure #1 is slightly more complex, using two analog gates rather than diodes to switch each orthogonal axis on and off. It has, however, the advantage of using only a single ended D.C. supply. To explain the operation of the circuit, a two phase D.C. clock (Note: It is not necessary that the pulse widths of the clock be equal) is used to switch a reference supply "V" alternately across the X and Y axis of the pad, simultaneously switching the wiper into X and Y detection circuits. The output X and Y pulses have amplitudes as a function of the wiper position. These pulses may be smoothed and used as control voltages (See Figure #2) or by properly selecting the pulse widths, the pulses can be used directly to control some external circuitry or device such as a T.V. game, computer cursor or machine tool.

In conclusion, there is now available to the designer a simple, inexpensive input device, rugged enough to withstand the abuse of consumer applications. The door is now open to applications in interactive graphics, character recognition and general control.

1 (ELLIS 1) T. O. Ellis and W. L. Sibley, "On the Development of Equitable Graphic 1/0", IEEE Transactions on Human Factors in Electronics, Vol. HFE-8, No.1, March 1967.

Bibliography

Fletcher, W.E., "ON-Line Input of Graphical Data", presented at the 1963 Digital Equipment Users Society Meeting, Livermore, California.

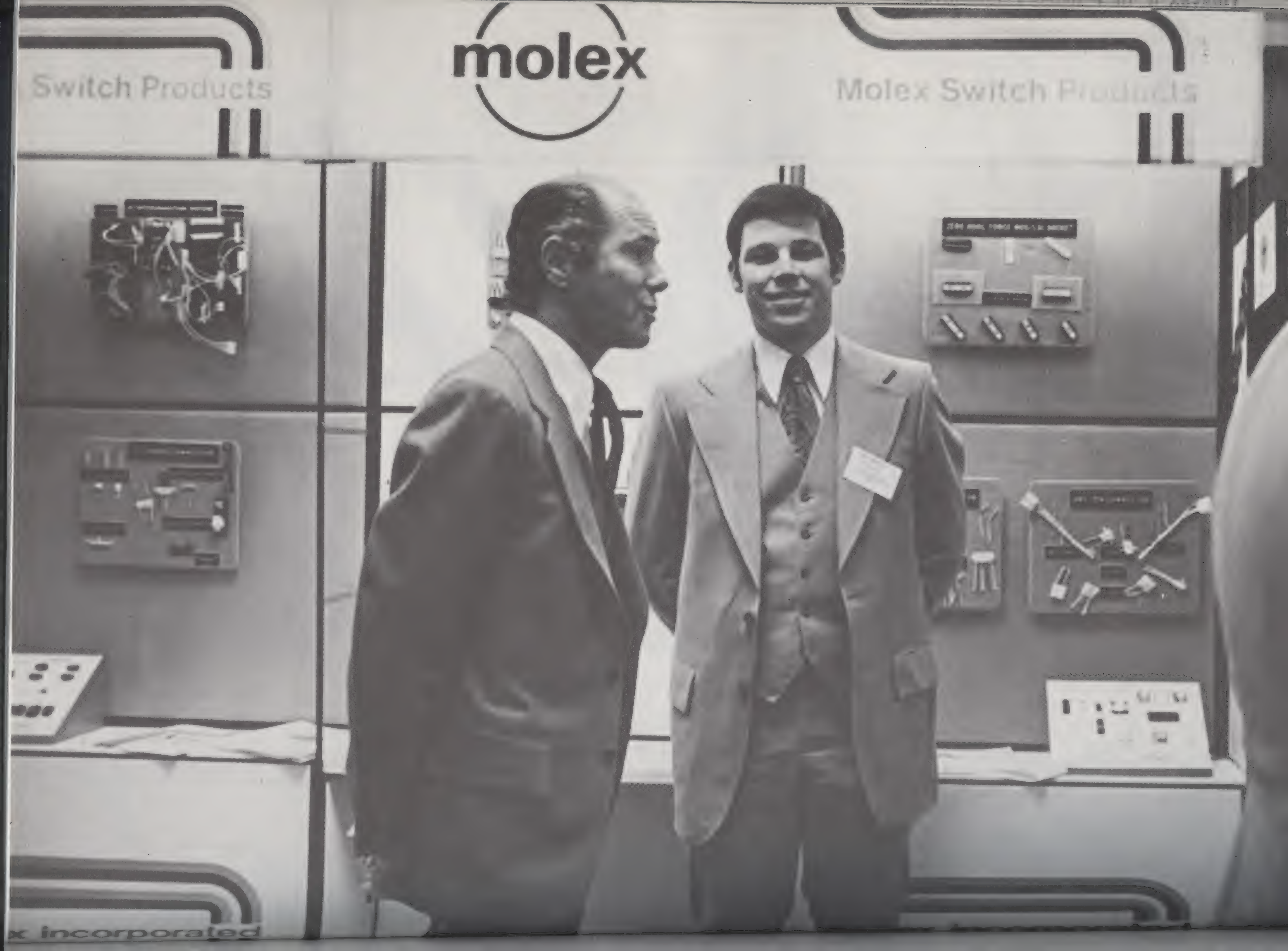
Note Lisa's control button.

Howerton, P.W. and Weeks, D.C., "Vistas In Information Handling", Vol.1, The Augmentation of Man's Intellect by Machine, Washington, D.C. Spartan Books, 1963.

Sutherland, I.E., "Sketchpad: A Man-Machine Graphical Communication System", Proc. 1963 Spring AFIPS Joint Computer Conf., Vol. 23 pp. 329-346.

Groner, G.F., "Real-Time Recognition of Handprinted Text", The Rand Corp., Santa Monica, California, RS-5016-ARPA, August 1966.

Malfunctioning electronic dolls also provided some light entertainment at Gametronics.


Switch Products
molex
Molex Switch Products
x incorporated

XVII THE SIX-IN-ONE TV GAME CHIP

LES PENNER
General Instrument Corp.
Hicksville, New York

The AY38500 six-game chip was the first single-chip LSI standard product to be made available to a broad base of video game manufacturers. This n-channel MOS chip was virtually single-handedly responsible for the millions of home video games that were sold in 1976, and for putting video games in the economical home-game category.

The first samples of the AY38500 were supplied to customers in February and March of 1976. The one millionth chip was shipped in August of 1976. In January, 1977, the seven millionth chip was shipped. It is anticipated that GI will continue to be shipping between 1 and 1.2 million circuits of this type per month.

There are actually two versions of the IC -- one for use in the 525-line, 60 half-frames-per-second NTSC system TV sets made in the U. S. and one designed for the 625-line, 50 half-frames-per-second PAL system employed in Europe.

The success of the AY38500 resulted from immediate acceptance by small to intermediate size companies, not the giants of the electronics industry or the established games manufacturers. These companies had the courage to arrange for financing and to extend themselves to venture into new areas.

Development of the AY38500 actually began in 1975 at GI's plant in Glenrothes, Scotland. The circuit was not the result of brilliant market forecasting or product planning. It is one or more of a dozen projects involving custom LSI that were underway at that time. The work was initiated for a European television manufacturing company which wanted to use it in its set. The original development work was based on meeting the European TV standard.

About the time that the European engineering group had reached the breadboard stage but prior to implement composite drawings for the MOS LSI chip, General Instrument decided to initiate a parallel effort to develop a chip which would meet the U. S. standard.

A team of 15 engineers in Hicksville, NY was put on the project.

To produce the game chips, p-channel wafer production facilities that had been set up to fabricate calculator chips were converted to produce n-channel game chips.

The need to increase high-speed testing capability was the next problem to be dealt with. After talking to various test equipment manufacturers, it was decided that the Macrodata

A Molex exhibit at Gametronics.

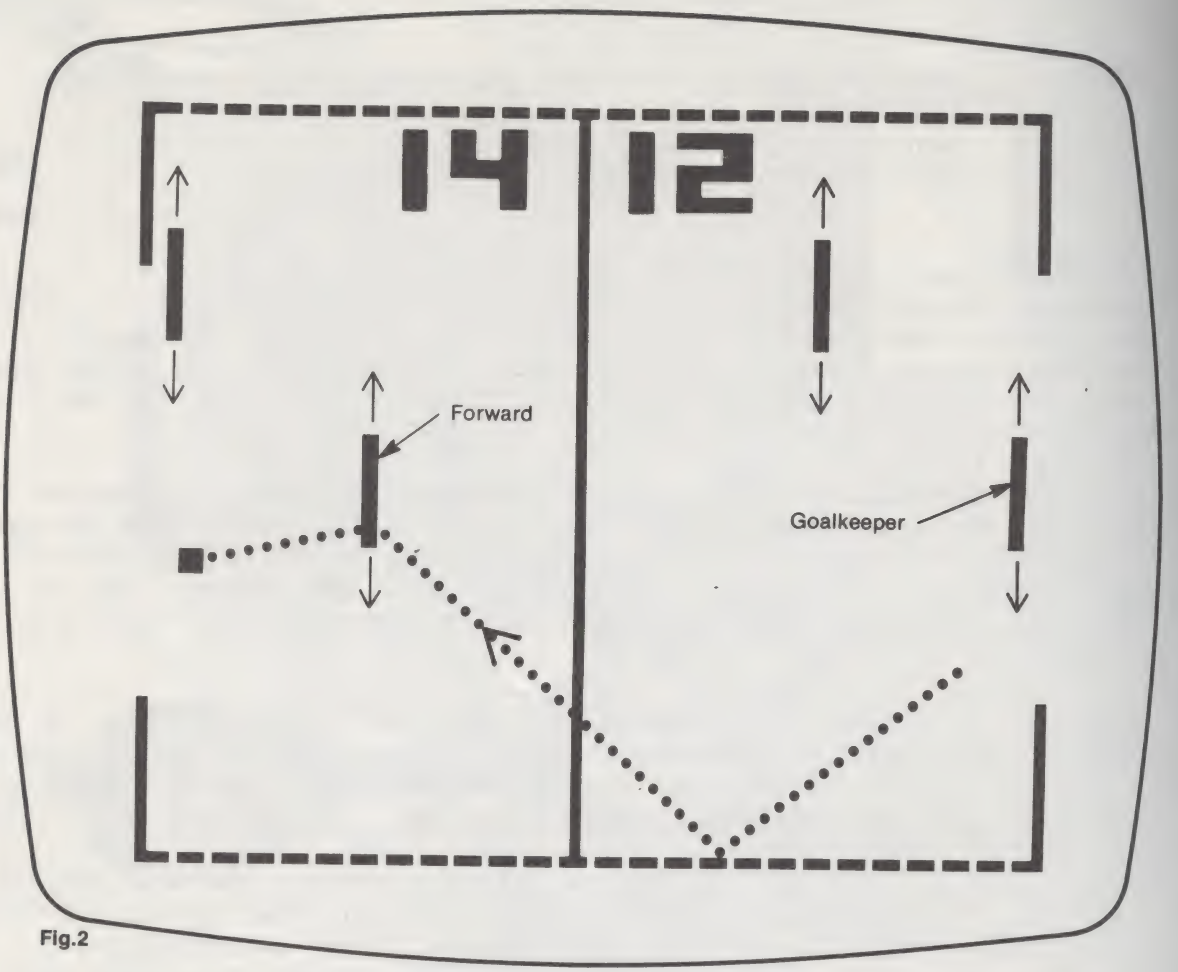


Fig.2

Soccer

The "soccer" type game is shown in Figure 2. With this game each participant has a 'goalkeeper' and a 'forward'. The layout is such that the 'goalkeeper' is in his normal position and the 'forward' is positioned in the opponent's half of the playing area.

When the game starts, the ball will appear travelling from one goal line towards the other side. If the opponent's forward can intercept the ball, (Figure 2a), he can 'shoot' it back towards the goal. If the ball is missed it will travel to the other half of the playing area and the first team's forward will have the opportunity of intercepting the ball and redirecting it forward at a new angle according to the 'player' section which is used (Figure 2b). If the ball is 'saved' by the 'goalkeeper' or it reflects back from the end boundary, the same forward will have the opportunity to intercept the outcoming ball and divert it back towards the 'goal'.

A 'score' is made in the "soccer" game by 'shooting' the ball through the defined goal area. The scoring and game control is done automatically as for the tennis game. The same audio signals are used to add atmosphere to the game.

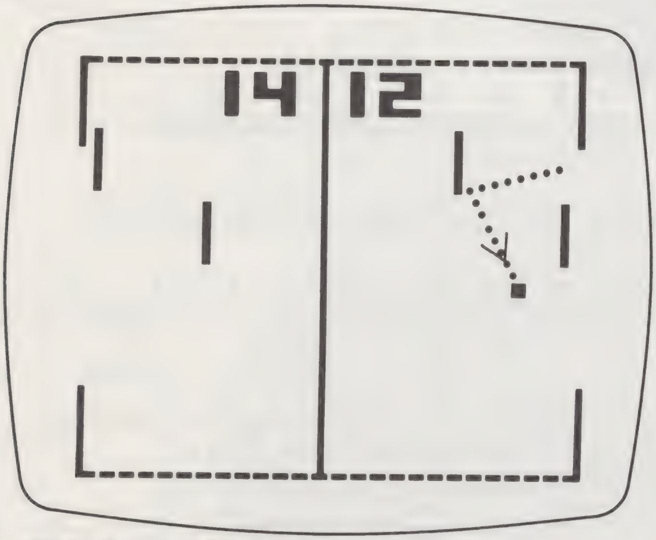


Fig.2a Return of "Goal Save"

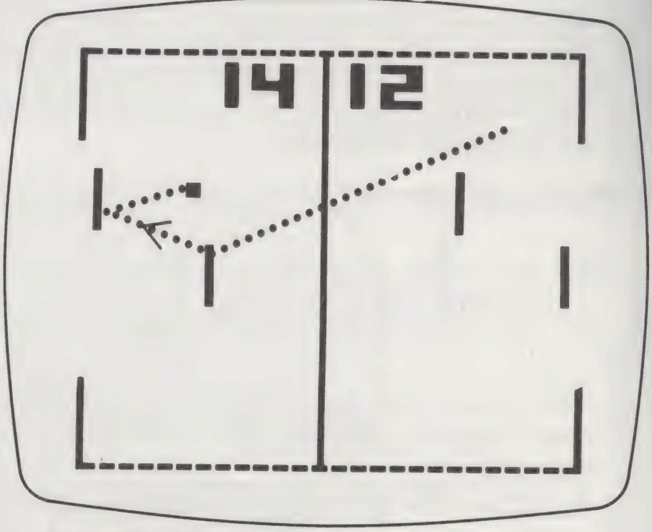


Fig.2b "Shooting" Forward

MG104 best answered the problem. The decision to use this test was made because of the speed at which it was capable of operating, its cost, the simplicity of programming it, and also because of the willingness of this company to work with us on a round-the-clock crash basis to provide us with the initial testers we needed to meet the demand for the game chips.

We needed about 30 test stations, all operating at 2 MHz, to test the devices. Although some equipment that could run at this speed and do the job required was selling for up to $150,000 per unit, we were able to purchase the testers for $25,000 to $30,000 each.

We found about ten test stations in house that we could use and bought 20 testers to meet the requirements for test stations.

We found that the test equipment could be brought on line. Testing was begun with actual operation of the game on the TV monitor. Fortunately, the performance of the IC could be observed on the television screen using special test exercising apparatus.

Skilled observers became so adept at exercising the game chips that malfunctions could often be correctly attributed to a particular transistor on the chip.

The AY38500 offered game designers many features including six selectable games -- tennis, soccer, squash, practice, all ball-and-paddle games, and two rifle-shooting games.

The chip provides automatic scoring and character generation on the chip for displaying two scores from zero to fifteen on the screen. The bat sizes are selectable externally, using switches. The angles are also selectable externally by switches as is the speed of the ball. Ball service can be automatic or manual after a score takes place as desired by the players.

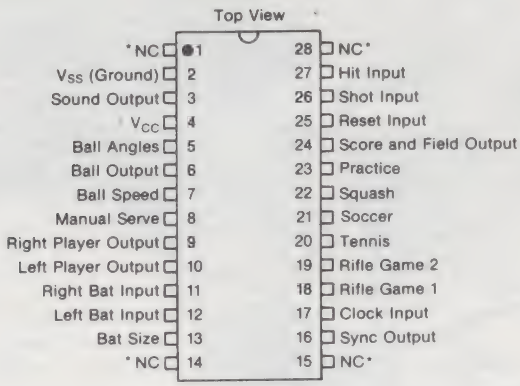
One of the main features of the chip was that it was very easy to use. It was self-contained with scoring, character generation, very simple sound interfacing and simple bat controls -- each a potentiometer and a capacitor. It used only 30 milliamperes, offering designers a rechargeable battery-powered option.

The chip also made it possible for manufacturers to produce games that differed from one another. Many manufacturers did not use all of the selectable features in order to keep costs down.

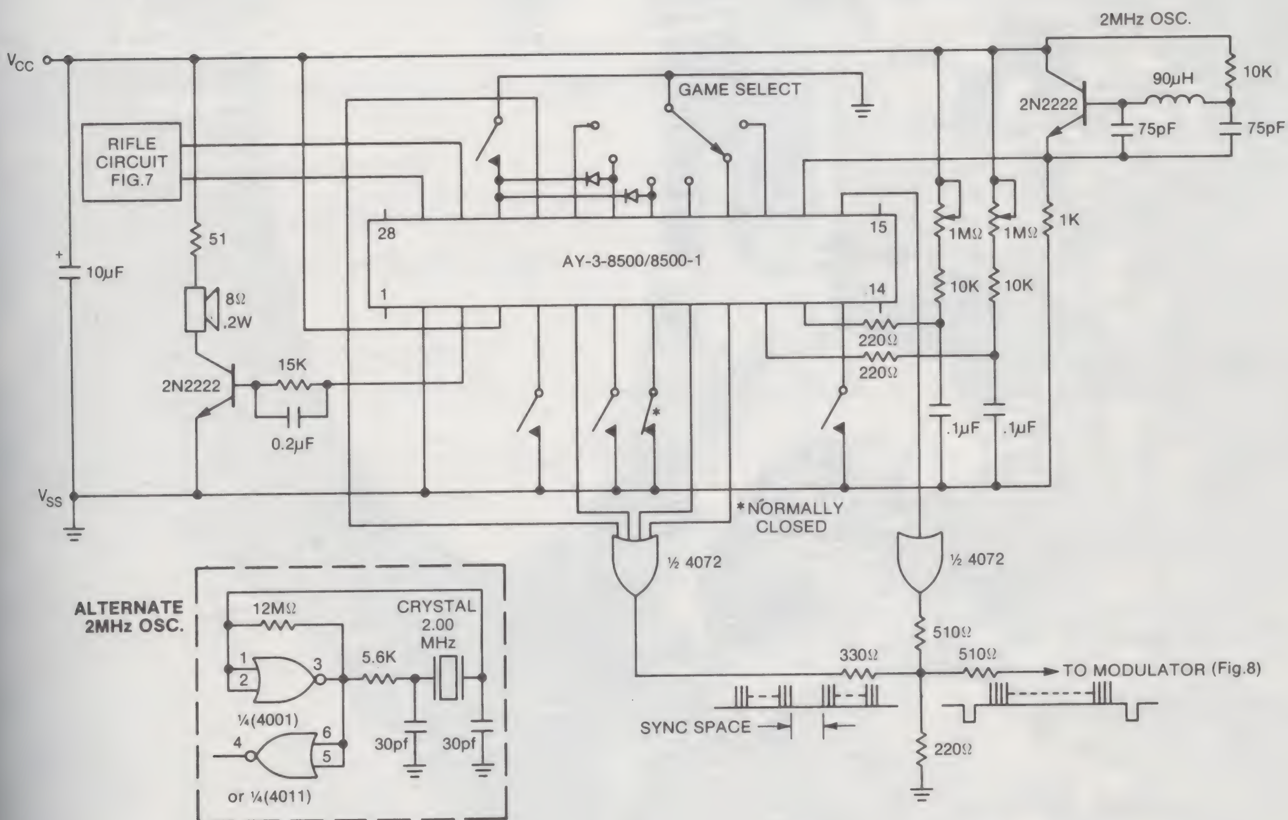
To support customers for the game chip, General Instrument also developed the external circuitry needed to use the chip in a game system; this included oscillators, speaker drivers and modulators.

Customers could introduce many modifications of their own. Because the pins are separately available, each player or team, the background and the scoring could be modulated in different colors. A four-player tennis option was also possible using the two-player chip. At least one customer did take advantage of this option.

28 LEAD DUAL IN LINE



*Do not use as tie point.



Ed Joiner, Chicago games consultant, at registration.

Pin Functions

(Pin numbers in parentheses)

Vss (2)
Negative supply input, nominally 0V(GND).

Sound Output (3)
The hit (32ms pulse/976Hz tone), boundary reflection (32ms pulse/488Hz tone) and score (32ms pulse/1.95KHz tone) sounds are output on this pin.

Vcc (4)
Positive supply input.

Ball Angles (5)
This input is left open circuit (Logic '1') to select two rebound angles and connected to Vss (Logic '0') to select four rebound angles. When two angles are selected they are $\pm 20°$, when four are selected they are $\pm 20°$ and $\pm 40°$. See Fig. 9.

Ball Output (6)
The ball video signal is output on this pin.

Ball Speed (7)
When this input is left open-circuit, low speed is selected (1.3 seconds for ball to traverse the screen). When connected to V_{SS} (Logic '0'), the high speed option is selected (0.65 seconds for ball to traverse the screen).

Manual Serve (8)
This input is connected to V_{SS} (Logic '0') for automatic serving. When left open circuit (Logic '1') the game stops after each score. The serve is indicated by momentarily connecting this input to V_{SS}.

Right Player Output/Left Player Output (9,10)
The video signals for the right and left players are output on separate pins.

Right Bat Input/Left Bat Input (11,12)
An R-C network connected to each of these inputs controls the vertical position of the bats. Use a 10K resistor in series with each pot.

Bat Size (13)
This input is left open circuit (Logic '1') to select large bats and connected to V_{SS} (Logic '0') to select small bats. For a 19" T.V. screen, large bats are 1.9" and small bats are 0.95" high.

Sync Output (16)
The T.V. vertical and horizontal sync signals are output on this pin. See Fig. 10.

Clock Input (17)
The 2MHz master timing clock is input to this pin. The exact frequency is 2.012160 $\pm 1\%$.

Rifle Game 1, Rifle Game 2, Tennis, Soccer, Squash, Practice (18 thru 23)
These inputs are normally left open circuit (Logic '1') and are connected to V_{SS} (Logic '0') to select the desired game.

Score and Field Output (24)
The score and field video signal is output on this pin.

Reset (25)
This input is connected momentarily to Vss (Logic '0') to reset the score counters and start a new game. Normally left open circuit.

Shot Input (26)
This input is driven by a positive pulse output of a monostable to indicate a "shot".

Hit Input (27)
This input is driven by a positive pulse output of a monostable which is triggered by the shot input if the target is on the sights of the rifle.

NOTE: The "Shot" and "Hit" inputs have on-chip pull-down resistors to Vss. All other inputs (except the "Bat" inputs) have on-chip pull-up resistors to Vcc.

Electrical Characteristics

Maximum Ratings*

Voltage on any pin with respect to V_{SS} pin .... -0.3 to +12V
Storage Temperature Range .... -20° C to +70° C
Ambient Operating Temperature Range .... 0° C to +40° C

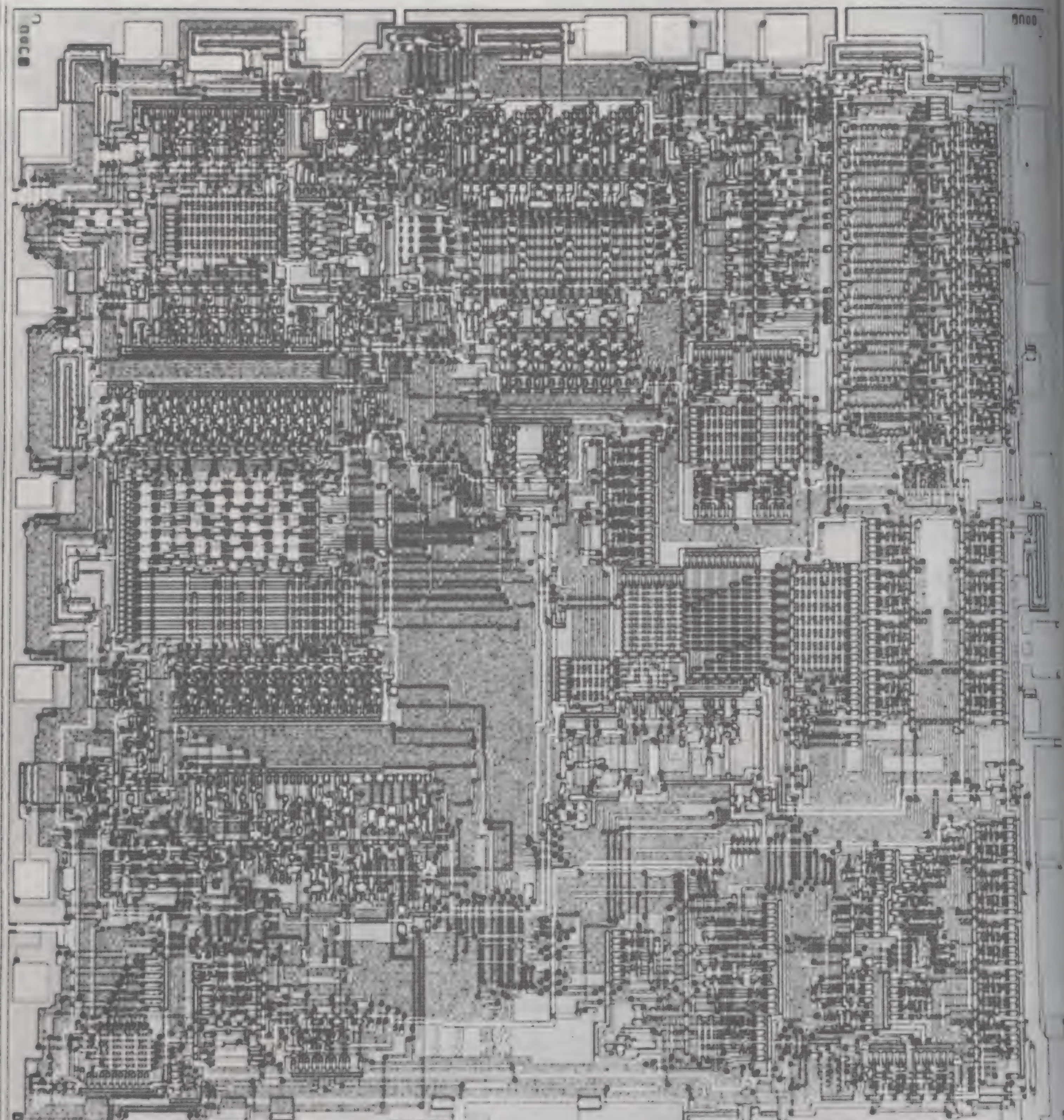
*Exceeding these ratings could cause permanent damage. Functional operation of these devices at these conditions is not implied — operating ranges are specified below.

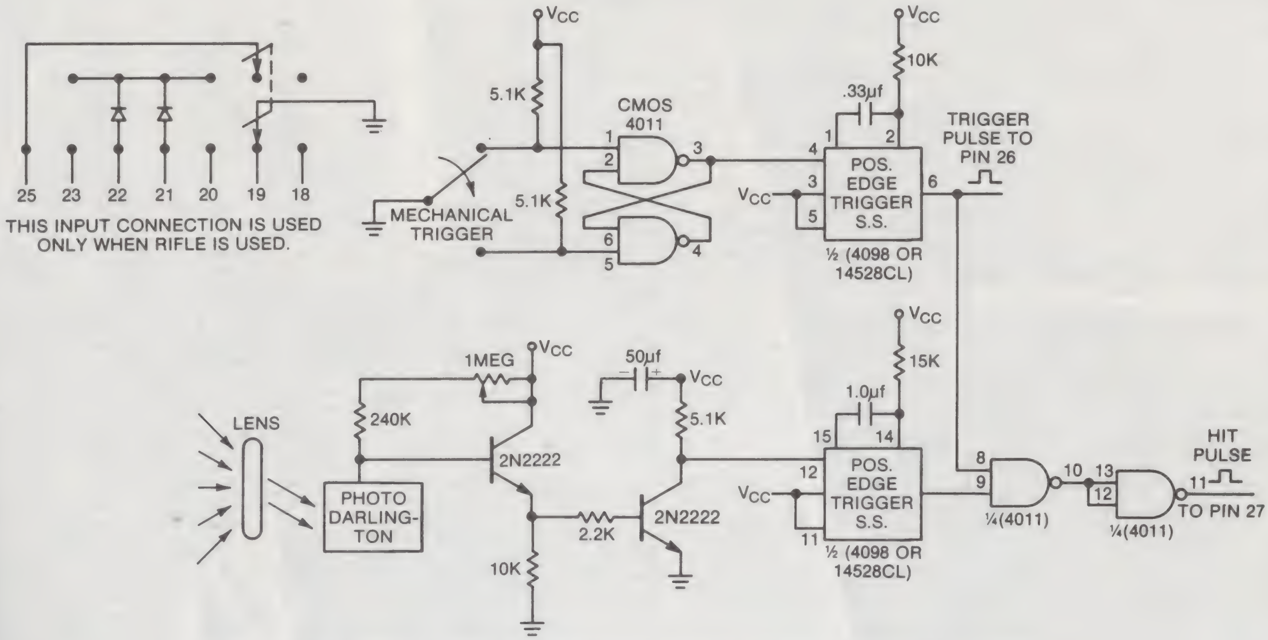
Standard Conditions (unless otherwise noted)

V_{CC} = +6 to +7V
V_{SS} = 0V
Operating Temperature (T_A) = 0° C to +40° C

Characteristics at 25° C and Vcc = +6 Volts	Min	Typ	Max	Units	Conditions
Clock Input					Maximum clock source impedance
Frequency	1.99	2.01	2.03	MHz	of 1K to V_{CC} or V_{SS}.
Logic '0'	0	—	0.5	Volts	
Logic '1'	V_{CC}-2	—	V_{CC}	Volts	
Pulse Width — Pos.	—	200	—	ns	
Pulse Width — Neg.	—	300	—	ns	
Capacitance	—	10	—	pF	V_{IN} = 0V, F = 1MHz
Leakage	—	100	—	μA	
Control Inputs					Max. contact resistance of 1K to V_{SS}
Logic '0'	0	—	0.5	Volts	
Logic '1'	V_{CC}-2	—	V_{CC}	Volts	
Input Impedance	—	1.0	—	M Ohms	Pull up to V_{CC}
Rifle Input	—	1.0	—	M Ohms	Pull down to V_{SS}
Outputs					
Logic '0'	—	—	1.0	Volt	I out = 0.5mA
Logic '1'	V_{CC}-2	—	—	Volts	I out = 0.1mA
Power Supply Current	—	40	60	mA	at V_{CC} = +8.5V

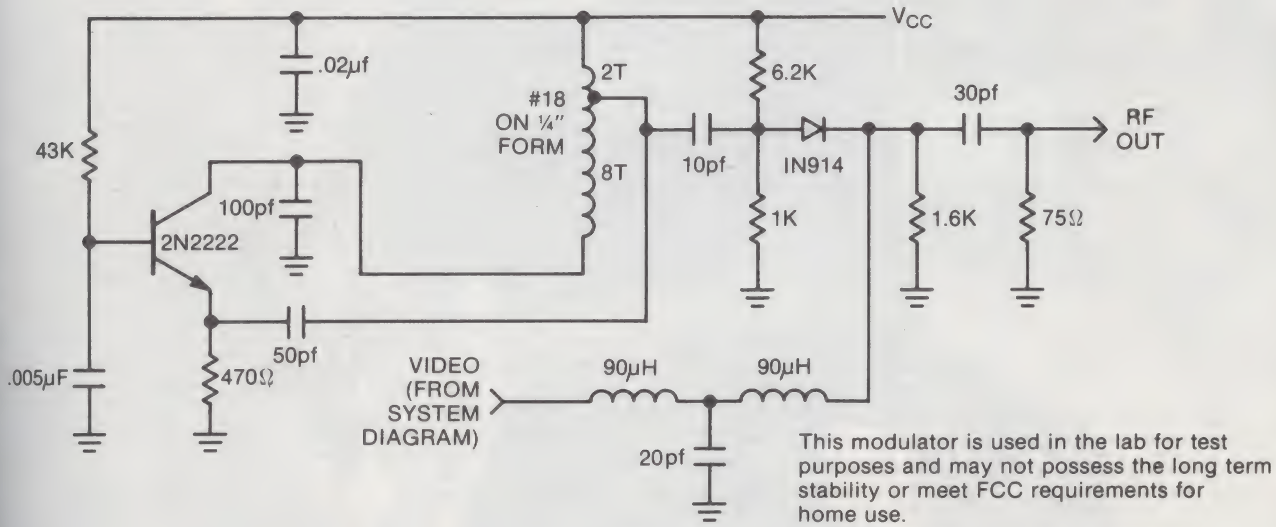
Opening ceremonies at Gametronics included simulated electronic music.





NOTE: Aim rifle at score on TV and adjust 1 meg pot. for max. voltage on pin 12 of the 4098 at a 6 ft. distance.
The Voltage at pin 12 should be 0 when there is no light on the TV screen.

Rifle Interface

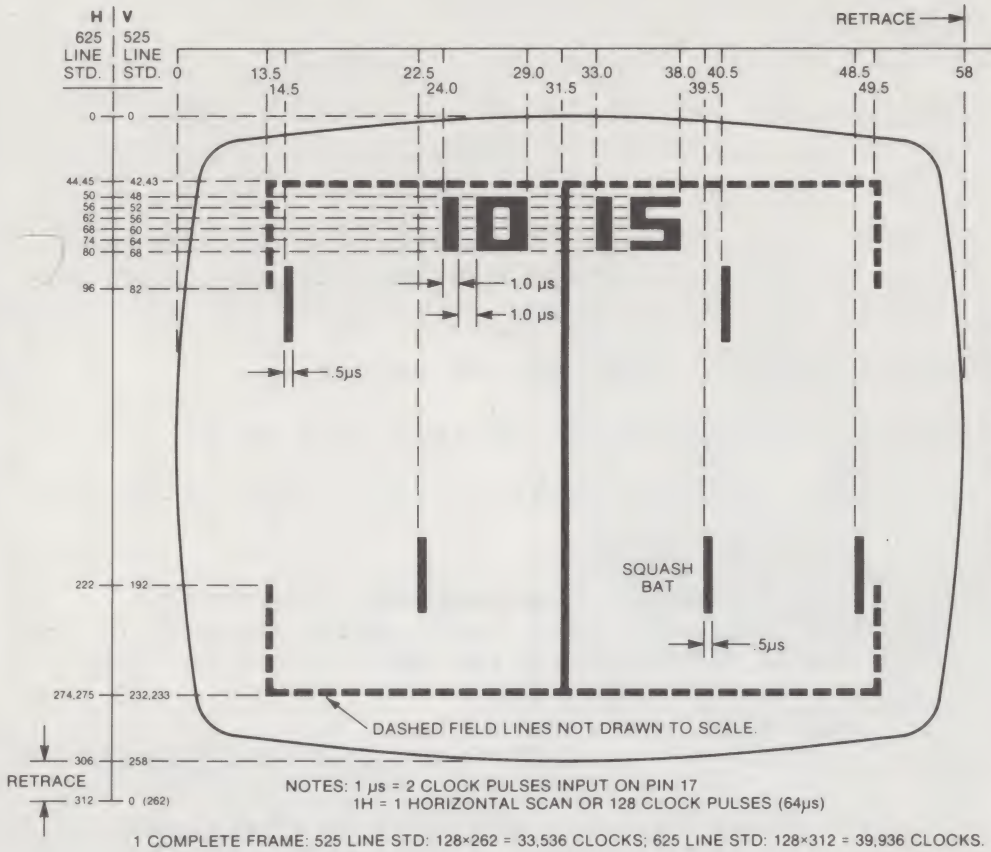


VHF Modulator

Chip view of the AY-3-8500.

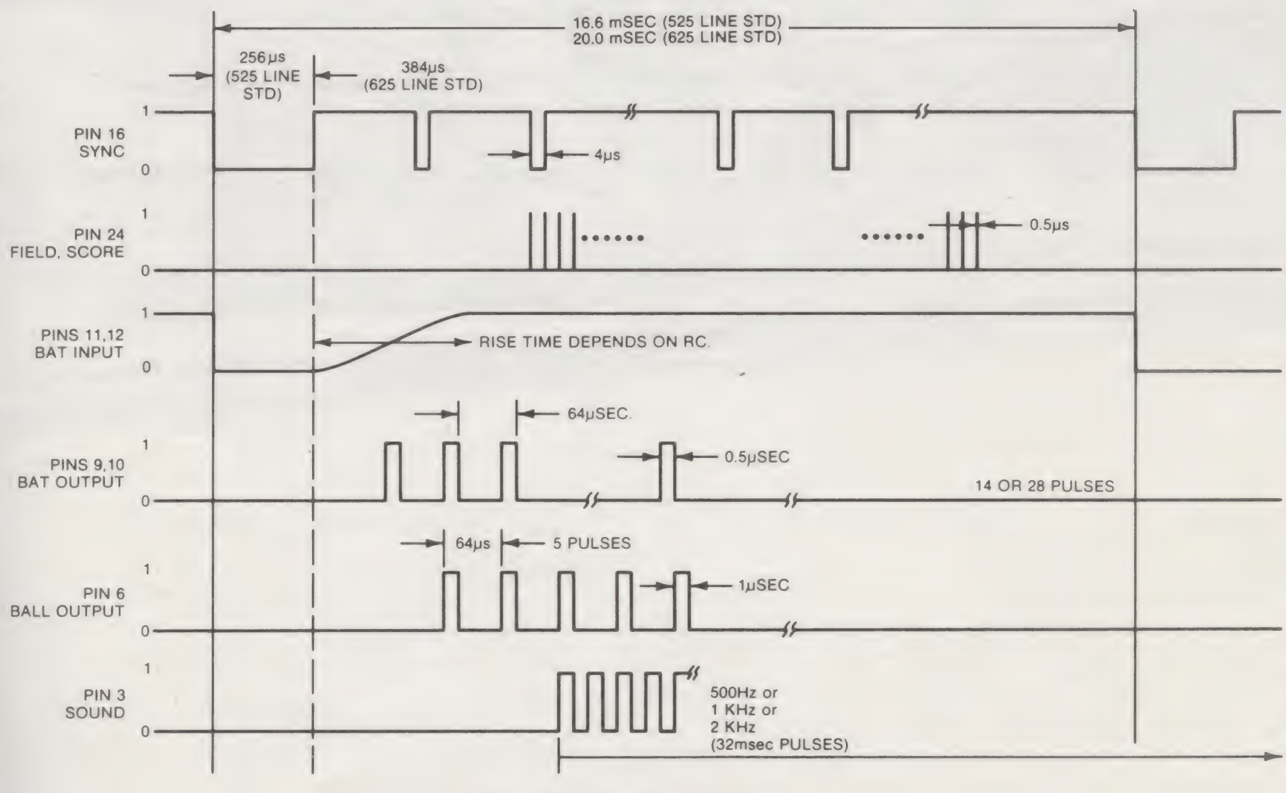
	Horizontal	**Vertical**
Slow	± .5µs	2 angles ± 1 line 4 angles ± 3 lines
Fast	± 1µs	2 angles ± 2 lines 4 angles ± 5 lines

Angular Motion



	H	V
BAT	0.5µs	14/28 lines
BALL	1.0µs	5 lines
TARGET	2.5µs	14 lines
FIELD	0.5µs	2 lines
525 LINE SCORE	5.0µs	20 lines
625 LINE SCORE	5.0µs	30 lines

Location of Data Output Pulses



Timing Diagram

Key to Photographs on Pages 197 to 208

Page 197: Odyssey 500, introduced by Magnavox in 1977 features player shapes in soccer, tennis, hockey and handball.

Page 198: National Semiconductor's Adversary. The three-game 1976 model is being upgraded to six games on one chip in 1977.

Page 199: Charles McEwan, president of Ramtek.

Page 200: Floor model version of Ramtek's "Hit Me."

Page 201: Production line for cocktail-table version of Hit Me.

Page 202: Four players against the machine. For this particular hand of Black Jack, being played on Ramtek's Hit Me, the machine was beaten by the three players at the left.

Page 203: Circuit-board for Innovative Coin's Spitfire.

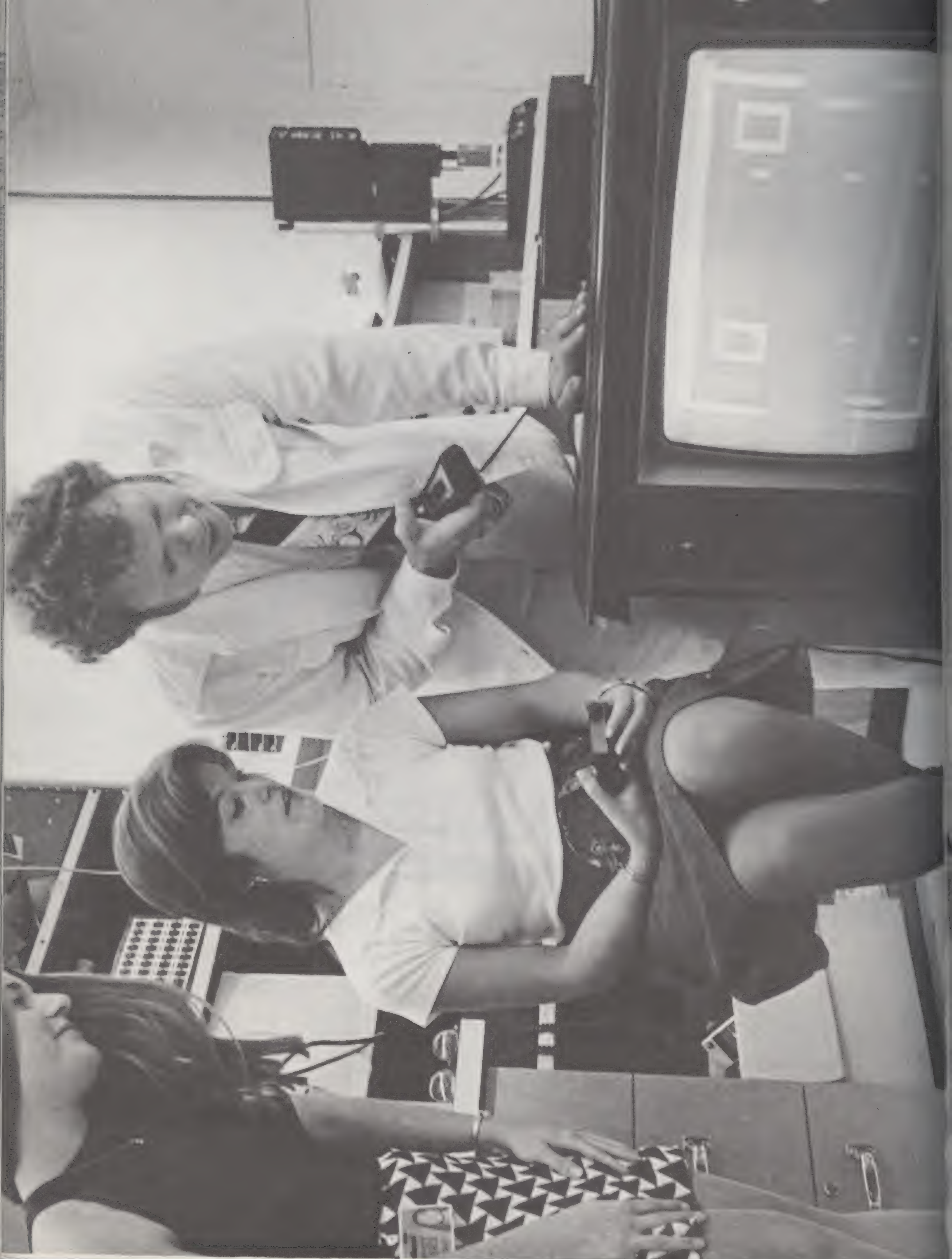
Page 204: Atari's "Touch Me" is a non-TV electronic game in which the player attempts to duplicate several bars of a song played by the machine.

Page 205: Sprint, one of Atari's racing games, pits competitors on various racing tracks.

Page 206: Atari's coin-operated game "Breakout" comes in floor console and table versions.

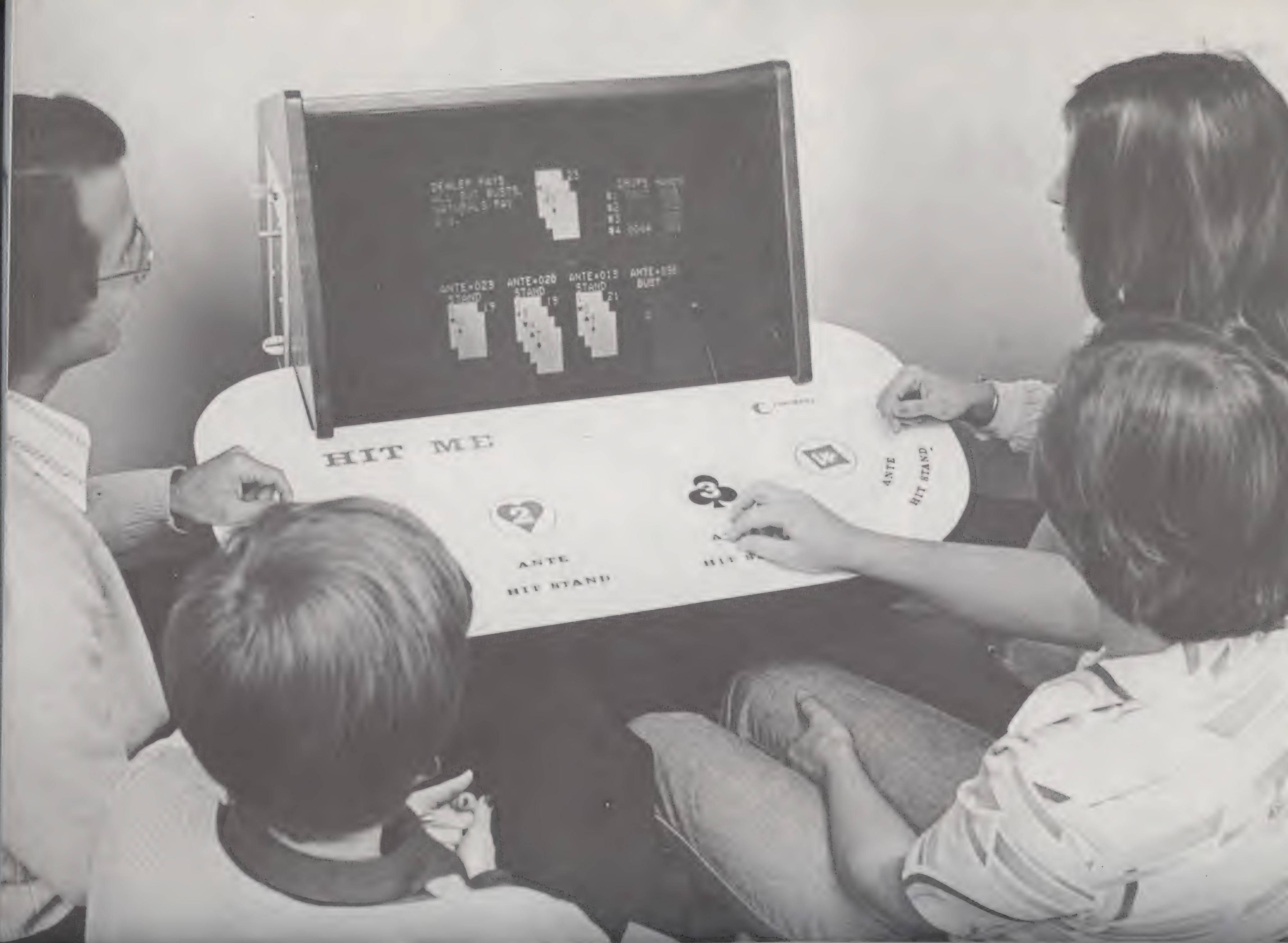
Page 207: Assembling of cocktail-table version of Breakout at Atari.

Page 208: Up to eight players can engage in combat when playing Atari's coin-operated tank warfare game.

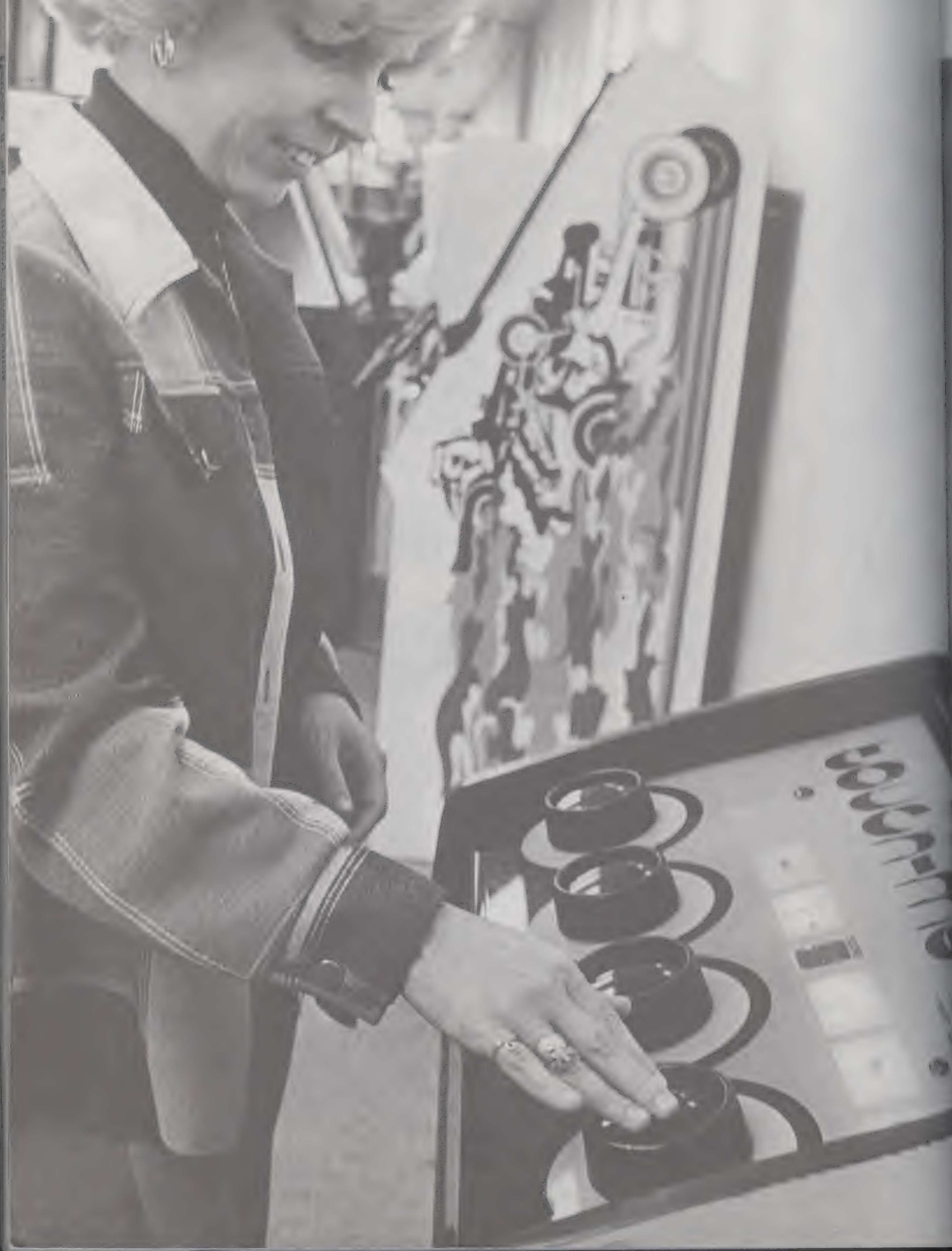



HIT ME
RAMTEK

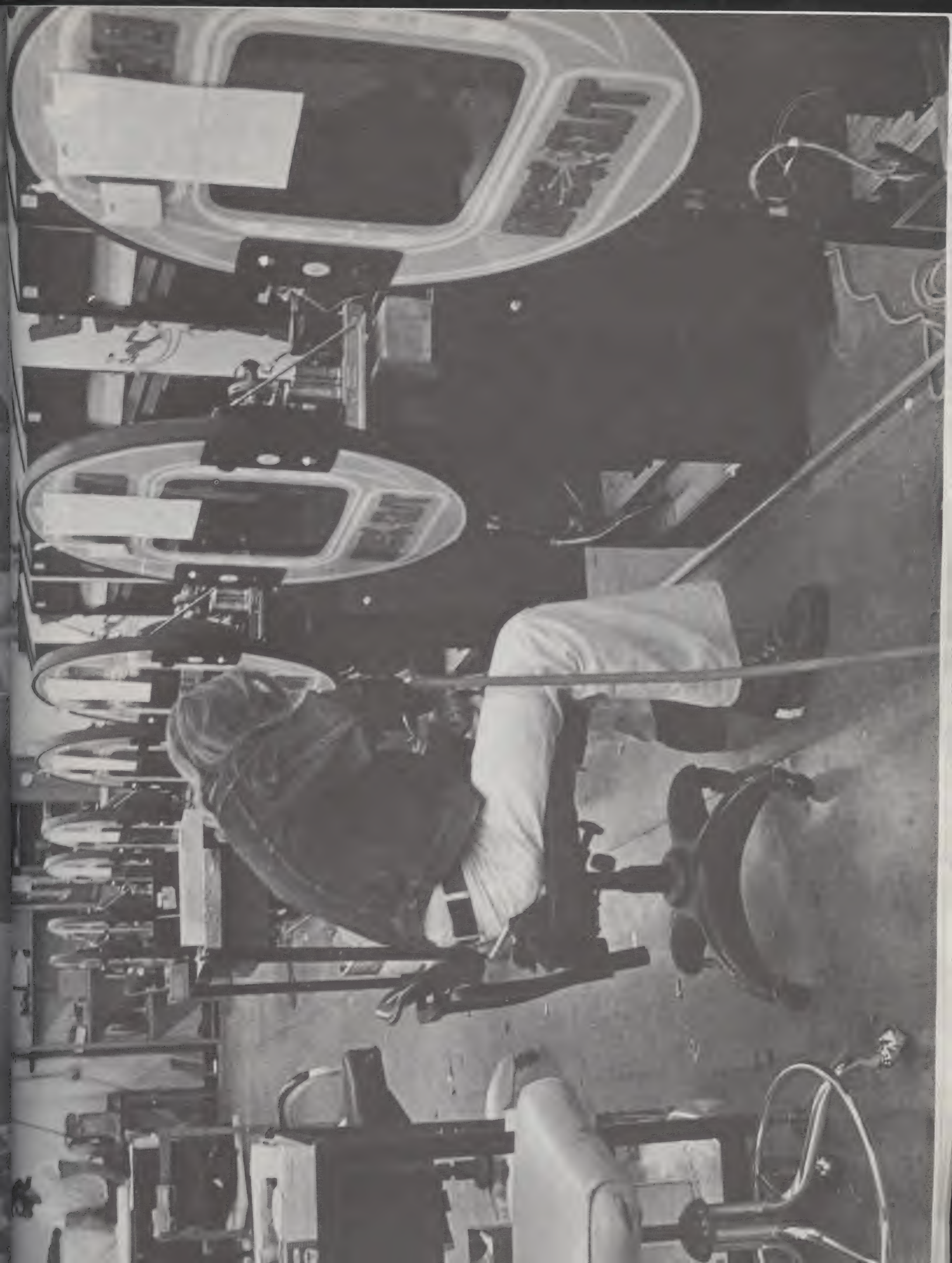

HIT ME
ANTE
HIT STAND
ANTE
HIT STAND


HIT ME
ANTE
HIT STAND
ANTE
HIT STAND


SPITFIRE




sprint
PLAYERS



XVIII. HOME ELECTRONIC GAME CATEGORIES

JERRY EIMBINDER
Electronic Engineering Times
Great Neck, New York

Today's home electronic games fall into twelve categories as shown in table one. The first category is dedicated TV games such as the Magnavox Odyssey series. There is an equivalent category in the coin-operated equipment business into which machines such as Atari's original Pong fall.

The second home electronic game cateogry lies between dedicated TV games and programmable TV games. It is called chip-alterable TV games and is illustrated by National Semiconductor's Adversary. To change the set of games available in an Adversary system, one master game chip can be substituted for another.

The original version of Adversary, introduced in fall, 1976 offered three games -- hockey, tennis and handball. Over 200,000 original Adversary games were sold in 1976 by National Semiconductor. Owners of these sets will be able to have their game chips replaced by newer devices as they become available.

Scheduled for June announcement is a new Adversary offering soccer, pinball, and "Wipeout" in addition to the original three games. Owners of existing Adversary sets will probably have to wait until National's own needs are satisfied before integrated circuits become available for upgrading of systems already sold.

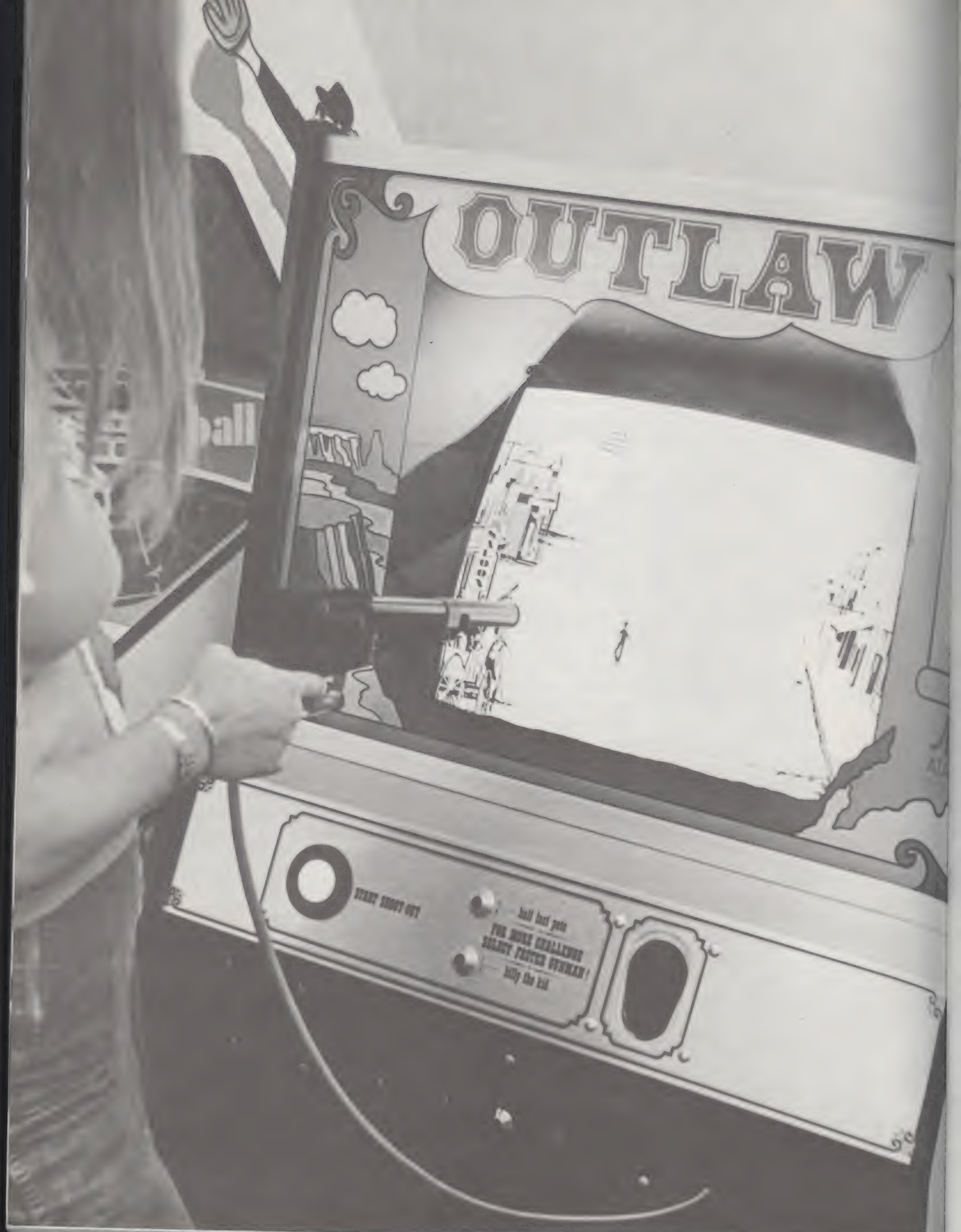
The next category is programmable home TV games.

The first home TV game to use replaceable cartridges was Fairchild's Video Entertainment System, available in limited quantities in August 1976. Each cartridge contains a semiconductor memory programmed to reproduce specific games on a television screen.

The system provides two resident games -- hockey and tennis.

The heart of the system is the game console, which includes a Fairchild F8 microprocessor and four solid-state random-access memories. For many games, the score and elapsed time are continuously displayed at the bottom of the screen.

The Fairchild unit uses eight-position hand controls. The controller can be pushed forward, pulled back, pulled left or right, twisted left or right, and pulled up or pushed down.


OUTLAW
START SHOOT OUT
half fast pete
billy the kid

When Fairchild introduced the Video Entertainment System in August, 1976, it hoped to develop a new cartridge for the system each month. But delays in getting approval for the system from the Federal Communications Commission set back Fairchild's timetable. Only a small supply of systems and three different cartridges were available for the Christmas, 1976, season.

In January, 1977, Fairchild revealed that it had developed three more cartridges, increasing its library to a total of six. The games provided by each cartridge are described in table two.

RCA revealed that it was developing a programmable TV game in September, 1976, and projected March, 1977, for initial deliveries.

The RCA unit employs its 1802 microprocessor and uses a keyboard to control action. There are two banks of keys with ten keys for each player. The system comes with five built-in game programs; additional programs are provided by plug-in semiconductor read-only memories.

The RCA system is the first TV game model to offer bowling. The alley is presented on the screen with the foul line running from left to right at the bottom of the screen. The ball is released when it is in the desired position by touching a key on the keyboard. Other keys provide "curve-up," "curve-down," or "no-curve" as desired by the player. The pins don't ricochet off each other; they are wiped of the screen if they are in the path of the ball.

Similarly, a TV-version of Etch-a-Sketch is controlled by pushing appropriate keyboard buttons for various directions of "etch" travel on the screen.

The fourth category is electronic game kits. TV game kits are an area of the market on the decline as a result of General Instrument's 6-games-on-a-chip AY-3-8500. The GI integrated circuit sealed the fate of the TV game kit business by dramatically lowering the cost of assembled games. Visulex, a pioneer in the TV game kit business, fared well for a time because it didn't have to get FCC approval in order to market a product. To continue in business, Visulex is redesigning its game kits so that they can be used in schools for training in circuit analysis and assembly techniques.

The next category is built-in TV games and is concerned with television receivers, such as one introduced by Magnavox during 1976, that include game generation as an integral part of the receiver.

In Atari's game "Outlaw," the player tests fast-draw ability against the machine's cowboy.


OUTLAW

Accessories form category six. These include products that are used with games such as a rifle containing a photocell. The photocell detects the presence of light moving on the screen if the player's aim is accurate. As game clubs evolve, accessories especially prepared for club scoring, ultiple competition and other club use will become available.

Self-contained home TV games, category seven, are stand-alone units requiring no hookup to a standard television receiver. A backgammon game, planned by Allied Leisure, qualifies for this category. Home computers, category eight, are one type of stand-alone equipment.

Non-TV home electronic games fall into four categories: console, board, pocket and mobile. The console category includes home pinball machines; the board category covers games equivalent to board games such as Chess (which may also be implemented as self-contained TV games); pocket refers to small portable games such as Mattel's calculator-size football and racing games. The mobile category refers to games in which movement of three-dimensional objects takes place.

Electronic coin-operated games can be divided into three major categories: arcade games, cocktail table games and gambling equipment.

1. Dedicated TV games	7. Self-contained TV games
2. Chip-alterable TV games	8. Home computers
3. Programmable TV games	9. Console games
4. Game kits & educational games	10. Board games
5. Built-in TV games	11. Pocket games
6. Accessories	12. Mobile games

Table 1. Categories of home electronic games

1. Tic-Tac-Toe (player pits X's against computer's O's)
   Shooting Gallery (electronic rifle vs flying ducks)
   Doodle (message or diagrams drawn on the screen)
   Quadra-Doodle (computer creates color kaleidoscope)

2. Desert Fox (mine and tank warfare)
   Shooting Gallery (angle of shot varies after hit)

3. Black Jack (played with Las Vegas rules)
   Double Black Jack (two players against the house)

4. Spitfire (a dogfight on the screen)

5. Space War (flying saucers fight using lasers)

6. Math Quiz (young players learn math basics)

Table 2. Fairchild Video Entertainment System cartridges

The machine loses.

XIX. GAMES DEVELOPED BY THE TV GAMES INDUSTRY

JERRY EIMBINDER
Electronic Engineering Times
Great Neck, New York

Many new games have been generated by the manufacturers of TV games. Some are variations of popular games; others are entirely original creations.

Not all manufacturers use the same name for virtually identical games. The best example seems to be handball. Some manufacturers prefer to call it squash if two players are involved and practice if it's the player against the machine. Anything but handball. Others call it handball whether it involves two players or one player practicing.

Some of the earlier non-conventional sports paddle games to evolve were Catch, Robot, Solitaire, Gridball and Hole.

In Catch, each player controls the movement of an opening in a vertical bar located at his end of the screen. A point is scored by moving the opening to a position which allows the ball to pass through. Hole is played in a similar manner.

Robot employs a large paddle which floats up and down blocking a goal. Scoring is accomplished by hitting the ball straight ahead or angling in a shot depending on the position of the robot. A near miss may rebound off the back of the robot and penetrate the goal.

Solitaire involves an adjustable-height wall with a space at the top through which a ball can pass. A point is scored by hitting the ball so that it clears the top of the wall.

Gridball involves three sets of vertically moving barriers, each containing three openings. The object of the game is to block the ball from approaching a player's end zone by advancing it towards the opponent's end.

Some of the more recent games developed by TV game manufacturers bear little or no resemblance to paddle-type games. Others are very thinly disquised versions of earlier games.

Protection is a combination of volleyball and hockey. The goals are located near the foot of the net, one on each side of the net. A player must prevent the ball from dropping through the goal opening after it is hit by the opposing player and clears the net. The ball may be played

An electronic game kit, manufactured by Visulex, is used as an educational system by schools.

off of all surfaces including the net and the back walls.

In Hazard, the object of the game is to keep from hitting the ball into a goal opening which moves around the boundary area in constant and random motion. If the ball goes through the moving goal, the last player to have hit the ball loses the point. The players must anticipate the location of the goal and hit the ball so that it hits a boundary which is not near the moving opening.

In Wipeout, 256 target dots appear on the screen; points are scored by hitting each target with a ball. As the ball hits the target, it disappears, hence the name Wipeout. The The player moves his paddle accordingly to aim at targets.

Wipeout can be played in a variety of modes. For example, two opposing players can independently hit balls on the screen to knock out targets. Another possibility is for two players to act as a team and work together in eliminating targets.

As the number of targets remaining is reduced, the target colors change and the number of points received for each target hit is increased. The back wall acts as a permanent, but moving, target and points are awarded each time a ball bounces off of it.

The idea in Barricade is to keep developing a path or track which does not cross itself or a path made by the opponent. If either player intersects his own path or the track of his opponent, his track stops, a new track begins at the origin, and a point is scored for the opponent.

LEM involves landing a spaceship on the moon safely. The player controls the rate of decent so that the ship is landed without expending the quantity of fuel available. If the ship lands at too high a rate of decent, it crashes and is destroyed. If all the fuel is used up before the ship reaches the lunar surface, it is overcome by the force of gravity and moves away from the surface of the moon. The ship must avoid meteor showers during its decent to a safe landing.

Because of a series of new game chips, announced by General Instrument in January 1977, a wide choice of game possibilities is available to TV game manufacturers. The manufacturers also have many options in adapting games available on the GI chips to customize their games. Games offered by the General Instrument multi-game chip series are tabulated in table one.

A cocktail-table game version of Tank is marketed by Kee Games, a division of Atari.


Bally
FIREBALL!

1. Tennis
2. Soccer
3. Squash
4. Practice
5. Rifle (Random Target)
6. Rifle (Straight Flight)

Ball and Paddle I Chip
(AY-3-8500)

1. Tennis
2. Soccer
3. Squash
4. Practice
5. Rifle (Random Target)
6. Rifle (Straight Flight)

Ball and Paddle IA Chip
(AY-3-8550)

Table 1(a). Games offered by General Instrument's six-in-one game chips. The AY-3-8550 offers the features provided by the AY-3-8500 plus additional features such as score color-coded to player, ball output coded to player in squash and scoring of both hits and misses in squash.

1. Tennis
2. Hockey
3. Soccer
4. Squash
5. Practice
6. Gridball
7. Basketball
8. Basketball Practice

Ball and Paddle II Chip
(AY-3-8600)

Table 1(b). Games offered by General Instrument's eight-in-one chip.

1. Tank Battle Game

Battle I

Table 1(c). Game involves two independently controllable tanks with 32 rotational angles, barricades and mines.

1. Black Jack
2. Slot Machine

Vegas I (AY-3-8888)

Table 1(d). Games offered by this chip simulate Las Vegas games. Black Jack follows Las Vegas rules.

1. Tic-Tac-Toe
2. LEM

Skill I (AY-3-8889)

Table 1(e). Games offered by this chip include the lunar landing game.

Description of game chip series available from General Instrument is continued on the next page.

Bally's $800 home electronic pinball machine.


GAMETRONICS
1977

1. Tennis (Position)
2. Tennis (Rate)
3. Hockey (Position)
4. Hockey (Rate)
5. Soccer (Position)
6. Soccer (Rate)
7. Practice (Position
8. Practice (Rate)
9. Basketball (Position I)
10. Basketball (Position II)
11. Basketball (Rate)
12. Gridball
13. Squash (Position)
14. Squash (Rate)

Ball and Paddle III (AY-3-8650, AY-3-8600)

Table 1(f). Game chip providing both position and rate games.

Note 1. In all position games, the ball starts at slow speed. If the high speed mode has been selected, the ball will switch to high speed after nine consecutive hits by the players without a goal being scored. The bats will be generated into five zones, each zone defining a different rebound angle. The zones listed from top of bat to bottom are nominally 40° up, 20° up, horizontal, 20° down, 40° down. A ball passing through a forward from behind will have its angle influenced as above, but not its left/right direction.

Note 2. In all rate games, the ball is put into motion when the players have properly depressed their serve buttons. The player who served or gained possession of the ball will continue to retain possession until he releases the serve button or has the ball intercepted by the opponent, who has his serve button depressed and intersects the carrier. In Soccer and Hockey, the ball will automatically release when the forward is in the vicinity of the goal mouth. After release, the ball will retain the speed and direction it had at time of release. On intersection with boundary or player, the ball will reflect with an angle equal to the angle of incidence. A player may change the speed and direction of the ball only by intersecting the ball with his serve button depressed. Possession will be retained until the serve button is released.

1. Black Jack
2. Draw Poker
3. ACEY/DEUCY
4. War

Cards (AY-3-8800)

Table 1(g). Home card entertainment game chip.

1. Combat Squares
2. Racing Squares
3. Shooting Squares
4. Juggle Game I
5. Juggle Game II

Square Off (AY-3-8601)

Table 1(h). Five squares game chip.

Sun Sigma's Edward Ho discusses game production in Taiwan.

1. Volleyball
2. Protection
3. Hazard

Volleyball Plus (AY-3-8602)

Table 1(i). Game chip offering volleyball and two similar games.

1. Barricade

(AY-3-8604)

Table 1(j). Collision avoiding game chip.

1. Road Race

(AY-3-8603)

Table 1(k). Racing game chip.

1. Submarine

(AY-3-8605)

Table 1(l). Submarine-ship battle game chip.

The games provided by the square off chip described in table 1(h) involve the manipulation of squares on the screen.

In Racing Squares, both players maneuver their squares around a maze-like race course. Each complete circuit of the course scores five points. If a player bangs into the wall while traveling the course, his opponent scores a point.

Shooting Squares is a target game. Each player fires missiles from his square at targets moving overhead. The targets move at various speeds and directions requiring constant adjustment of time and direction of fire.

In Combat Squares, a player must maneuver his square into a position from which he can launch a missile at his opponent's square. Random barriers provide protection against missiles. Missiles can be directed to follow curved paths as the controls are turned.

In Juggle I, players launch missiles at each other and then guide the missiles past obstacles into the opponent's half of the playing area. A player can take over control of a missile coming into his area and return it to his opponent. Juggle II is similar, except that only one missile is used.

Road Race involves steering a car down a road filled with traffic without colliding with any of the cars being passed. The game ends when one of the players has had 15 collisions. In Submarine, the surface commander launches depth charges while the submarine captain counters with torpedoes.

Commodore's home computer PET was demonstrated at Gametronics.
Next Page: Atari's original Pong, introduced in 1972.


PONG
13
2

GAMETRONICS PROCEEDINGS